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USS

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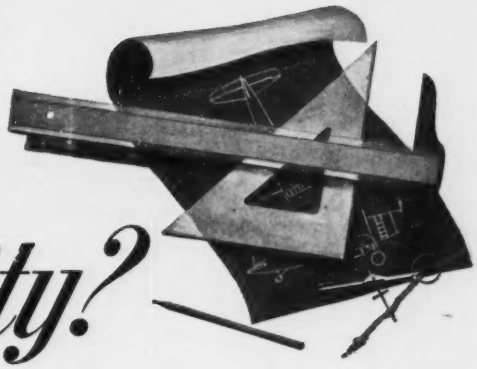

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GOODYEAR AIRCRAFT

"Willie wants to be President!

"Of our Student Council, that is.

"That's him over there, passing out his campaign handbills like an alderman passing out cigars.

"Our school elections used to be pretty dull. You know, a couple of funny posters put up in the halls, and that was about it.

"But our new Civics teacher, Mr. Leszczynski, has a theory that we'll learn a heck of a lot more about government and Americanism if we have less reading and more *doing*.

"He started out last year by making two school Parties . . . conventions, platforms and all that. And, while we had a lot of fun with our elections, we learned a lot about government at the same time. We've even got a regular Congress . . . with teachers in our Senate and us pupils in our House of Representatives. All elected by us, too.

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"He's not so dumb, either. He must've figured we'd sort of take our lessons home and pass them along to our families. 'Cause since he came to our school, our Parent-Teacher's meetings have been standing-room-only.

"And last regular Election Day in town, more'n 80% of our parents voted. I know both of mine did . . . and so did my big brothers and sisters.

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"To show you what us kids think about him . . . he's the *only* teacher we don't have a nickname for behind his back."

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* * *

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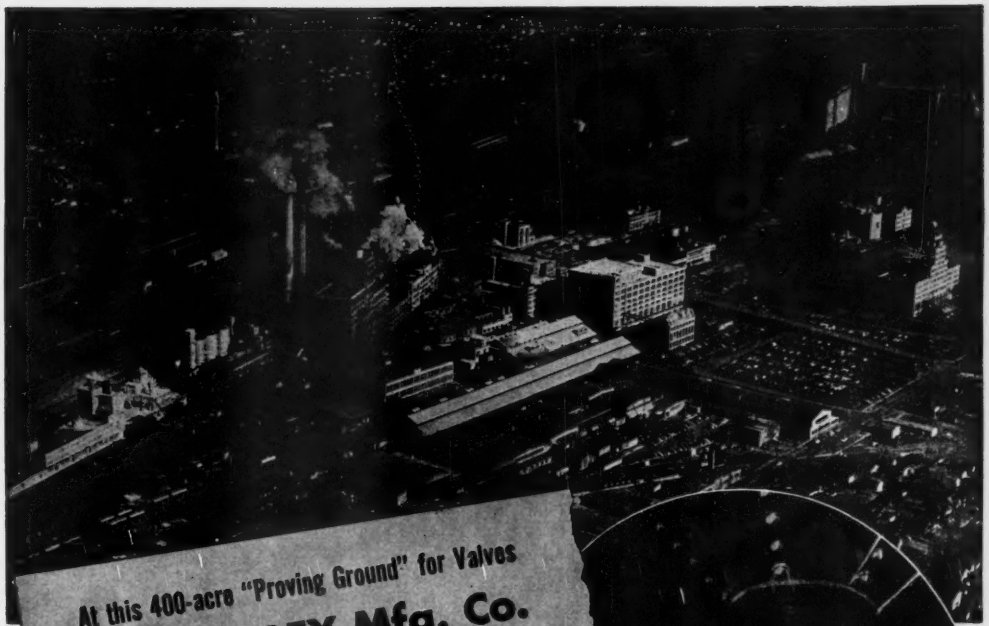
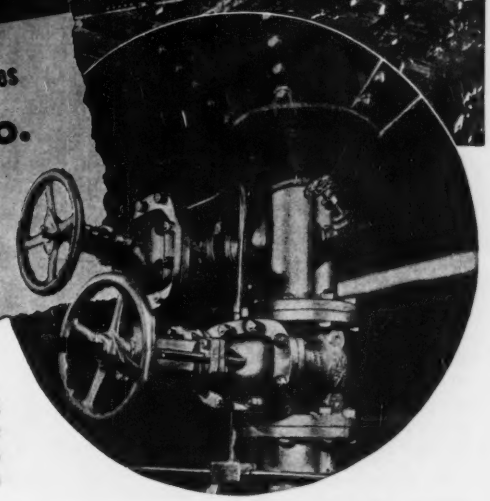


At this 400-acre "Proving Ground" for Valves

A. E. STALEY Mfg. Co.

consults past performance records . . .

repeats choice of JENKINS VALVES



If you set out to build an industrial "proving ground" for valves, it could include few tougher tests than those imposed in normal services at this 108-building plant for the manufacture of Staley's Corn and Soy Bean Products at Decatur, Illinois.

Processing heavy syrups and concentrates soon seeks out any weak spots in valve design and construction. The punishing work load on valves imposed by tremendous volumes of fluids handled is indicated by the water requirements alone,—over 20,000,000 gallons a day.

Previous experience with the low-cost performance of Jenkins Valves led to their repeated choice for 30 new buildings constructed as part of Staley's multi-million dollar post-war expansion program.

This confidence in the *extra measure* of efficiency and endurance built into Jenkins Valves is shared by plant operating managements in every type of industry.

Despite this extra value, *they pay no more* for Jenkins Valves. For new installations, for all replacements, the Jenkins Diamond is their guide to lasting valve economy. Jenkins Bros., 100 Park Ave., New York 17.

CONTROLLING FLOW from a syrup blending tank (above) requires valves that are "maintenance misers". These are some of the thousands of Jenkins Valves in the Staley plant on water, steam, and processing pipelines, and on compressed air piping serving pneumatic ducts for dry products.

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VALVES

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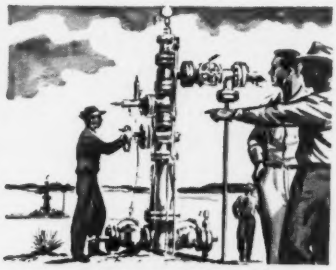
NATURAL GASOLINE DEPARTMENT extracts light hydrocarbons from natural gas. Phillips is the world's largest producer of natural gas.



NATURAL GAS DEPARTMENT produces, gathers and sells natural gas in the development of one of the world's largest gas reserves.

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Whenever fastening problems arise...

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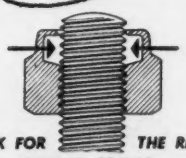

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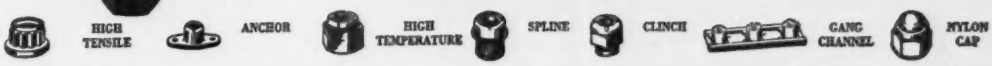

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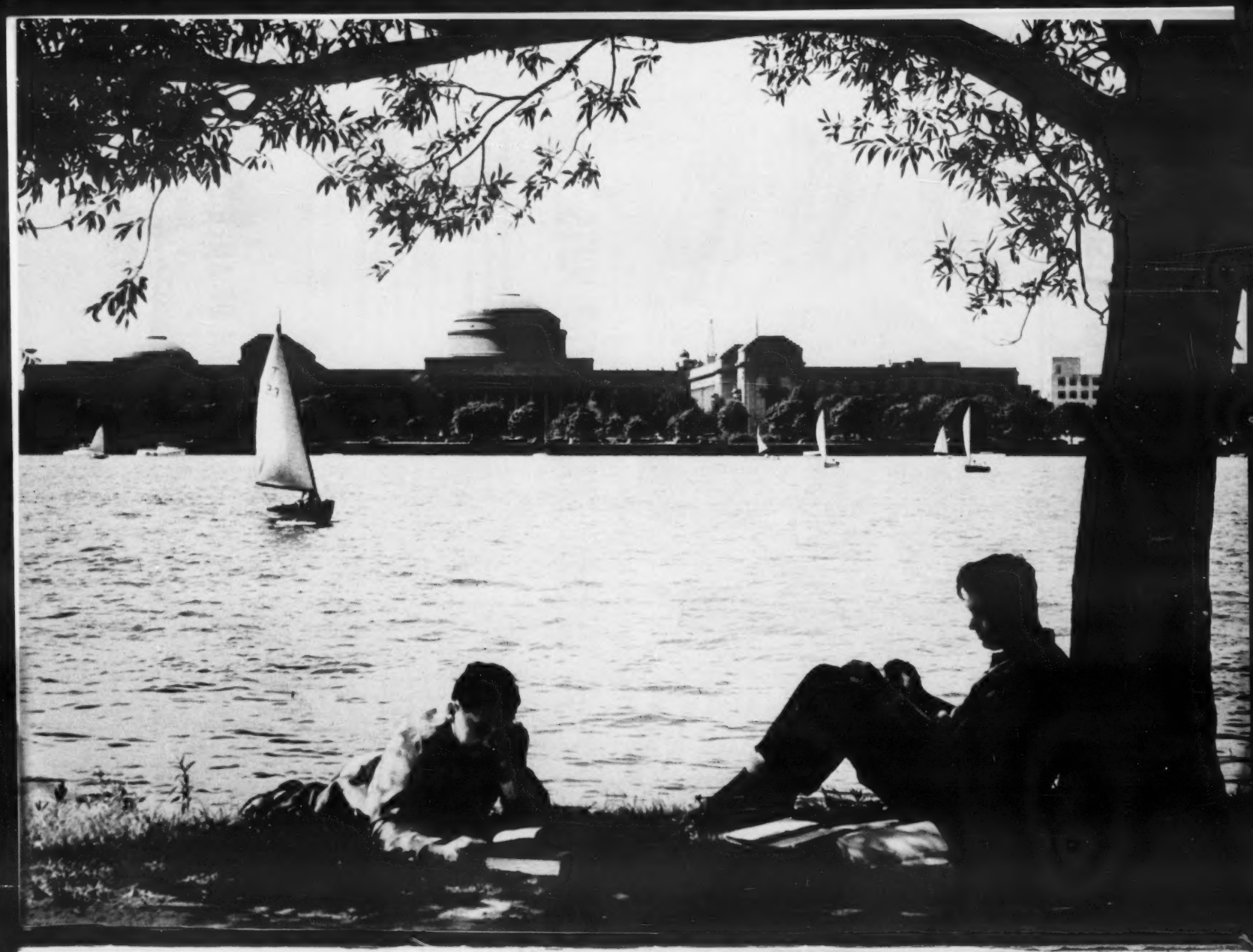

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the technologist as man and citizen

By Dean E. Francis Bowditch

There are many questions on the minds of students, faculty members, and administrators at M. I. T. They are questions which arise out of the confusion and problems of our age, the answers to which are vital to the future of our country, to individual liberty, and to world peace. They are questions which no one man can answer but which must somehow be answered by the combined efforts of us all. In discussing these problems, I cannot pretend to speak for all of M. I. T.; I raise just one voice which I trust will be answered and joined by many others that together we may reach final conclusions.

The editors of *T. E. N.* posed essentially three questions to me: First, is the modern engineer or scientist narrow-minded, lacking in social development? If so, what should be done about it? They pointed out that the present program requires a rigorous daily schedule of classroom and laboratory work, plus hours of preparation; there is little time left for extra-curricular activities, athletics, and, perhaps most important of all, reflection and philosophizing. In other words, they ask: are we training specialists who, as men — as fathers, administrators, citizens — are inadequately trained to use their specialized knowledge for the benefit of society and to play a significant role as citizens?

The second question deals with the most treasured ideal of American democracy and the most zealously guarded tradition of the Institute: individual freedom. They ask: what is individual freedom at M. I. T.? What is individual responsibility? Is the level of conduct at M. I. T. as high as it should be? If not, what level should it attain? What are the effects of granting so much freedom? What are the risks? Does it not automatically produce too low a level of conduct? In short, the very fundamental American question is raised: what is the source and what is the price of individual freedom?

E. Francis Bowditch, Dean of Students at Tech since last year.

The third question follows very logically and is closely related to the second: what of the role of student government at M. I. T.? Is it a valid role? The same underlying worry and concern typical of our times is apparent in this question. In essence, the question says to us: life is badly mixed up; apparently we are using our traditional forms of government but they are not working. What is wrong? What changes must we make?

All these questions are manifestations of the basic questions of our times, questions being raised over and over again by young adults as they inherit from the older generation the responsibilities of parenthood, management, and government. The questions, jostling each other like waters of the mountain stream joined in the rushing current of the river, are confused and clouded. Must we find brand new answers to man's problems? Were our forefathers all wrong? Could the discoveries of the scientific age have changed the nature of man? Could the great leaders of early America, or of our great industrial development, have been all wrong? Were the great teachers of old off the track?

Enough of questions. Our main concern is to so understand the times in which we live, and the modern M. I. T., a product and part of the times, that we may see at least a glimmer of the answers on the horizon of the future.

It seems to me perfectly clear that many of the questions we have in our minds today, many of the problems to which we must find a solution result directly from what we might call the scientific revolution of the Western World, a revolution in which England, Germany, France, and the United States have been the leaders, but in which all the countries of the world can now join and are hastening so to do. Through the development of mathematics and the scientific method which is based on mathematics, man has learned in a very short period of time to fly through the air at unbelievable speed, to communicate with his fellow man anywhere in the world at a moment's notice. He can so harness the powers of nature that his daily needs for existence, as well as his material comforts, are taken care of easily and with little time and effort. He has more leisure than he has ever known. Goaded by fear and hatred, man has now split the atom to release a power which may destroy civilization as we know it unless we learn how to control it.

There have been many changes in our environment as a result of this scientific progress. A town meeting of the world could be called and held in twenty-four hours. At the meeting we Americans could learn, if we were humble enough, that the white race is a minority race and that Christianity is a minority religion in the world. At home, we have flocked to the cities, created

(*Continued on page 26*)

full steam ahead!

Steam Power Solves Defects of Modern Car

By Jerry Tiemann, '53

The modern car is certainly one of today's most notable engineering accomplishments. The real accomplishment is not so much the actual development of a device suitable for travel as it is the successful overcoming of the basic faults of the gasoline engine. The gasoline engine is primarily a constant speed, constant power engine. At low speeds, not only does it tend to buck and stall, but the power output falls off practically to nothing. To get out of this difficulty elaborate gear systems and clutches have had to be designed. The bucking and stalling have been eliminated by automatic choking devices and fluid drive transmissions. The noise and vibration of the engine were dealt with by installing mufflers, shock mounts and soundproof bodies. Throughout the years one thing and another have been added, some to overcome the disadvantages of the gas engine directly, others to overcome the disadvantages of the other gadgets, until now no one but a skilled mechanic would dare tamper with the innards of a car. It has come to the point where no one but a mechanic can figure out just what the various parts of the engine are actually supposed to do.

But at last engineers have succeeded in forcing the proverbial square peg in the round hole, and we have an automobile satisfactorily, though inefficiently, powered by gasoline. Had the engineers been willing to admit the obvious and forsake the internal combustion engine for a more suitable power source, they probably would have turned to steam long ago. Not only would they have eliminated all the major disadvantages of the gasoline engine at one stroke, but they would have gotten many other advantages which are unthinkable in an internal combustion engine. And they would have gotten these benefits at no cost in efficiency. In fact, since a steam engine can run on any low-grade fuel, such as oil burner oil or kerosene, the cost per mile of the fuel actually would be considerably less. There is a story of a man travelling from Los Angeles to New York on $4.50 worth of furnace oil.

There is no need for a transmission in a steam driven car. Full power can be developed at any engine speed. Furthermore, there is no engine noise. One of the most spectacular things about a steam car is the way it can leap ahead with unmatched acceleration in total silence. A steam engine can spin the wheels of the car from the very start, as can some gasoline cars, but gone is the roar of the engine and shifting of gears. The car just goes. Equally unheard of is the way a steam car handles on hills. There is no need for racing at the bottom. The engine can actually store energy in the form of high pressure steam and heat in boiler which can be drawn upon at will. A steam car can climb any hill on which the tires can maintain traction at any speed whatsoever. A favorite trick of drivers when they had to stop on a hill was to turn the throttle back almost all the way, letting the steam pressure hold the car from rolling back. When they want to start up again, there is no slipping of clutches and letting off emergency brakes. The driver merely shoves the throttle back up, and the car glides forward completely mindless of the hill.

The most important advantage of the steam car is

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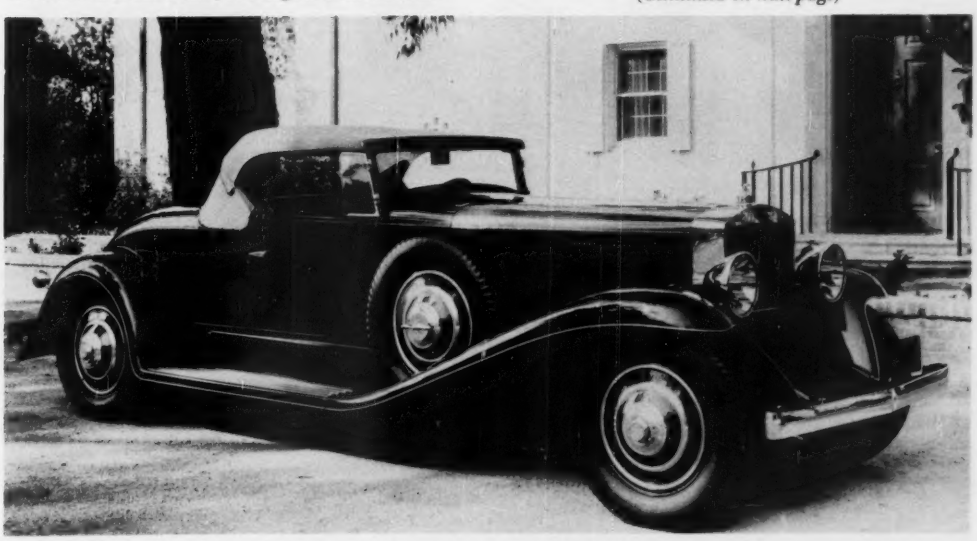
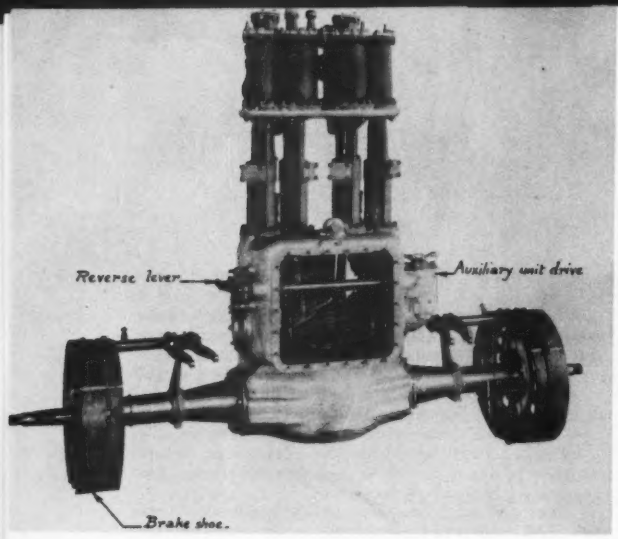


A Doble steam car made in the early thirties along the lines of a European sporting car. The long hood contains the boiler; the engine is in the rear.



(Above) The powerful, compact engine of the Doble cars. No transmission is needed. The engine also acts as a brake.

(Below) A rear view of a steam roadster still in use. This car was built early in the Depression but still can match present-day gasoline models. The engine is in the curved trunklike box behind the driver's seat. The driver sits over the water tank. The front hood carries the boiler and condenser units. (Photos courtesy *Motor Trends*.)

that while starting, or passing, or in any other situation where a lot of power is needed, the steam engine can deliver up to three times the continuous rating of the engine; this means ninety horsepower with a thirty horsepower unit. The reason for this is the aforementioned ability of the steam engine to store up a reserve of power. In addition to the added safety which comes from the additional power, a much smaller, cheaper, and lighter engine can be used to power the car. Modern gas engines cannot do this, of course, so they have to be able to develop continuously the maximum horsepower the car needs.

When designing a car, the first difficulty one encounters is the problem of applying power to the front wheels and steer them at the same time. The cheapest way out, although the worst way from the point of view of riding comfort, is to power the back wheels. The logical place for the engine, then, is in the rear. Since the gearbox has to be some place between the gasoline engine and the differential, the engine was placed all the way up in front. The result is a rather poor distribution of weight. No such difficulty is encountered in a steam car. There is no transmission which needs controlling, and the throttle can be any place on the steam intake pipe. The engine can be mounted right on the differential. Not only are power losses in the clutch and transmission eliminated, but the weight distribution is also much better. The Stanley Steamer Company, true to the engineering profession, solved the problem of poor weight distribution by placing the three hundred pound boiler up front under the hood.

There are many interesting stories about Stanley Steamers. Although there was almost no attempt to make the car comfortable to ride in, the Stanley was unquestionably the best car on the road in its day. It had no shock absorbers, and the whole engine-rear axle assembly was not suspended from the springs. When nearly all the weight of the car is on the springs, the wheels follow the bumps while the body, because of its inertia, rides in a relatively level plane. Nevertheless the Stanley was more comfortable than any other car on the road. Why? Because it was powered by steam. The lack of vibration and noise more than made up for what it lacked in springing. The Stanley was also the fastest car on the road. A specially designed racing car

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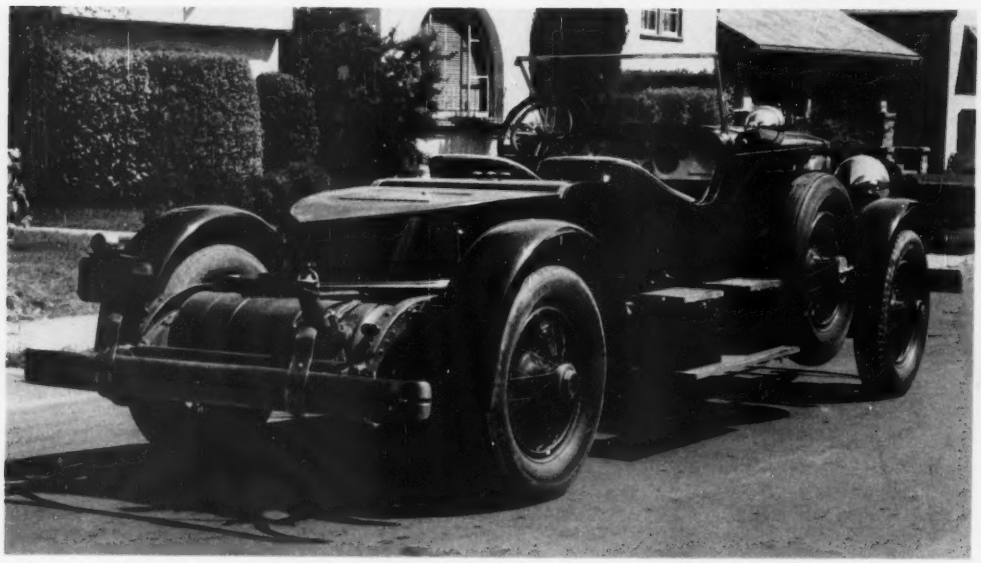

challenges of communication

By Arnold Levine, '53

Gregariousness finds its origin in human helplessness. No other animal is so dependent upon others for survival. Because of this dependence, the desire to keep in contact with others is universal and so great in human beings that some psychologists have thought it inborn.

For centuries, man, the "social animal," sought faster and more convenient means of communication. With the advent of the first great technical revolution in communications — the invention of the telephone and telegraph — progress in this direction became amazingly rapid. The physical barriers which held up progress for centuries were suddenly by-passed. The nineteenth century thinker, so awed by the innovations, inaugurated the era with a question expressing anxiety, distrust, and hope. "What," they asked, "hath God wrought?"

However, anxiety soon gave way to great expectations. Improvements were made, one upon the other, and the world became a tight little island, surrounded on all sides by itself. Surely the expectations of the nineteenth century were being realized in the twentieth. Improved communications had enabled businesses to integrate themselves and become more efficient; they had facilitated the spread of scientific ideas and, thereby, speeded progress in other fields. They had made it possible for men to appreciate the intellectual ideas of other cultures and widened the perspective of the layman by sending him news from every part of the globe.

To a great extent the twentieth century has justified the anxieties of the nineteenth. Modern communications made possible the destructive cartel and the giant World War. Indeed, the existence of the latter has produced a climate of opinion among nations which threatens to deprive us of the fruits of world-wide communication. In fact, it is this stifling "climate" which is the problem of our age. It is becoming more and more apparent that research and invention aimed at improving our ships, passenger planes, and communication systems will be in vain if there is no place to go and no one to talk to. Even rocket research loses its meaning when we realize that the first nation to reach the moon will try to prevent others from doing the same.

Within the last few years a second revolution in communications has occurred which may indicate the way out of the dilemma. The revolution is not one in new applications, but in new attitudes. It concerns itself not with the how of sending messages, but with what can be sent. Before attempting to show the implications of the new ideas, it is necessary to present a brief description of them.

There are several important aspects of this subject. First there is the technical, which concerns itself with the accuracy of transmission of information. The second is the semantics of the transmitted message. Third is the psychological problems which are concerned with the motives of the sender and the influence of the message on the receiver. And last is the sociological problem which is concerned with the effects of interculture communication. We will consider the technical problem first.

Dr. Claude E. Shannon of Bell Telephone Laboratories is primarily responsible for the "Mathematical Theory of Information" as it relates to engineering communications. The discussion which follows is a brief interpretation of a few salient points in Dr. Shannon's work.

The word "communication" is defined as the transference of information through time or space or both. A communication system, the arrangement used in the transference, can be abstracted into five components: information source, transmitter, channel, receiver, and destination. The purpose of the transmitter is to encode the information in order that it may be sent over the channel. The receiver decodes the message and hands it on to the destination. The concept of information is extremely important in this theory and is not related directly to the ordinary sense of the word. *Rather it refers to the possible number of signals that can be sent over the channel.* The *amount* of information is measured by the $\log_2 N$, where N refers to the number of alternative signals. Thus, if I have the choice of sending only a dot or dash over a telegraph line, I would have two choices, and the amount of information these two symbols represent is unity ($\log_2 2 = 1$). The dimension of information is called the bit. Thus, the dot and dash represent one bit of information. One might think that the length of a message might be a measure of its information. But this is evidently not true even when we use the word in its ordinary sense, for we can make a list of nonsense syllables indefinitely long. On the other hand, one might consider that using the number of alternatives alone would suffice as a measure of information. However, Dr. Shannon offers as one of his reasons for using the logarithm the fact that, "Parameters of engineering importance tend to vary linearly with the logarithm of the number of possibilities." He cites as an example that doubling the time roughly squares the number of possible messages, or doubles the log.

The measurement of information in the above manner is valid only when the alternative symbol or messages can occur with equal probability. By "equal probability" we mean that every symbol appears as often as every other symbol if we count the number over a long period of time. Such an arrangement has no resemblance to language. An approximation to language is achieved if we consider a set of symbols which have different probabilities of occurrence, and whose probabilities of occurrence vary with the immediately preceding signal.

Shannon formulates the problem as follows. Let $Pi(J)$ represent the probability that letter i will follow j, let $P(I,J)$ represent the diagram probabilities, the relative frequency of the diagram ij, and let $P(i)$ represent the probability of letter i occurring. We then arrive at the following formulas:

$$P(i) = \sum_j P(I,J) = \sum_j P(J,I) = \sum_j P(j)\, P(i)$$

$$P(I,J) = P(i)\, P(j)$$

$$\sum_j P_i(j) = \sum_i P(i) = \sum_{i,j} P(I,J) = 1$$

where j represents all letters of the alphabet in turn.

(*Continued on page 39*)

A central view of the Great Spiral Nebula in Andromeda. This center is composed of billions of stars like the sun. Our own Milky Way would look almost exactly like this if seen from Andromeda, a distance of 680,000 light years. Our sun would be on one of the spiral arms off the edge of the picture.

the riddle of the stars

Whence Stellar Energy?

By D. F. Shrader

What are the stars? How can we explain their apparently inexhaustible energy production? These questions are not easy to answer, because it is difficult to move the sun into a laboratory and analyze it. But the answer to the riddle probably gives an important clue to an age-old question: What is the universe? Where did it come from? What will happen to it in the future?

Unfortunately the astronomer works under a handicap unknown to other scientists; he is billions of miles away from the objects he investigates. Also, his lifetime is too short for him to observe the change of the universe as a whole with time. But, by patient watching and sometimes clever guessing, he knows far more about the inaccessible interiors of distant stars than he probably does about his own wife's "woman's intuition." For a great deal of valuable information can be gleaned from the light which reaches the earth from space.

The astronomer knows that stars are hot gaseous spheres whose matter has properties that are undreamed of on earth. Stellar material is at a temperature and pressure that render it almost unrecognizable as ordinary matter. It assumes an enormous range of densities, from thousands of tons per cubic inch to 10^{-15} grams per cubic centimeter. The pressure within ordinary stars varies from billions of atmospheres on the central portions to sometimes less than 0.001 atm. at the surface. Our earthly laboratories simply cannot approach the conditions of the stellar interior; we must be content to observe our distant stellar companions.

Naturally the state of matter under such extreme conditions is far different than it is under "ordinary" temperatures and pressures. Stellar chemistry is rendered very simple; no molecules of any kind are stable. Not only are molecules broken up, but even the outer layers of electrons on all atoms are removed. The lightest elements are completely stripped of their electrons, and only the bare nucleus remains. The electrons which have been freed by collisions hurtle through the mass at terrific speeds. Very often they are captured momentarily by one of the highly ionized atoms, but a collision knocks another electron out of the capturing atom quickly. In the steady state, the only thing that escapes from the chaotic center is the radiation, which on the average streams outward and is finally emitted at the surface. The radiation itself is absorbed and reradiated so many times in the superdense interior that, even though it travels with the speed of light, it takes millions of years for the energy released at the center to be radiated into space.

But although stars vary greatly in surface tempera-

The Great Nebula in Orion. The black blotch extending into the nebula is interstellar dust between us and the nebula. Not all of the light comes directly from stars; the interstellar gases fluoresce due to the intense radiation from nearby hot, blue stars.

ture, area, and luminosity (amount of light radiated), they do have one thing in common; a mass of between 10^{32} and 10^{35} grams (our sun has 2×10^{33} grams of matter in it). There must be something special that happens when 10^{33} grams of matter is brought together. What? And why?

In order to attack this problem, astronomers brought out their biggest weapons: pencils and reams of paper. Sir Arthur Eddington did pioneer work in considering a star to be made up of a perfect gas which was contracting under its own gravity. As the gas collapses inward, its gravitational energy is converted into heat. Naturally the mass will glow when hot enough. The mass will stop contracting only when the pressure of the outer layers of gas is counterbalanced by the outward pressure of the gas plus the pressure of the radiation streaming outward. In our terrestrial experiments this radiation pressure, which is actually equal to the energy of the radiation per unit volume, is almost always too small to be at all significant. But Eddington suspected that it would be important in stellar interiors. And he was right!

A calculation of the ratio of the radiation pressure to the gas pressure acting within a collapsing gaseous sphere gives interesting results. Suppose we are given a mass and its molecular weight. The mass determines the gravitational energy, the loss of which in turn determines the temperature. The radiation pressure is proportional to the fourth power of the temperature. the temperature, and hence the pressure, increases rapidly with the mass. The result of the calculations: the gas pressure and radiation pressure are about equal for masses of 10^{32} to 10^{35} grams! This indicates that when the radiation pressure is comparable to gas pressure, the system becomes stable and forms what we call a star.

But a few more calculations added a very large fly to the ointment; it turns out that the gas should radiate all of its gravitational energy in some twenty million years. True, this is quite a while. But the radioactive mineral deposits in our earth indicate that the earth is about 1.6 to 2.5 billion years old, and the earliest forms appeared some one billion years ago. So the old question still remains: where does a star get its energy?

In this atomic age the answer seems to be rather obvious; there must be some nuclear reaction for transforming the star's mass into energy. The phenomenal temperatures of millions of degrees can be reached by gravitational contraction alone. At these temperatures, nuclear reactions which cannot ordinarily take place, or are far too slow to be perceptible, can go with readiness. Scientists know that the reaction must go rather slowly even at stellar temperatures, or else the star would explode. It probably involves hydrogen and helium, the primary constituents of stellar gas. In 1938 Dr. Hans Bethe hit upon a series of reactions which predicts, assuming a reasonable internal temperature of the sun at twenty million degrees, the exact amount of radiation emitted by the sun. This "carbon-nitrogen" cycle doubtlessly is the main energy-producing reaction in the universe.

The energy-forming series of reactions can be assumed to start with ordinary carbon, C^{12}. The carbon can absorb a proton (hydrogen ion) and form unstable N^{13} plus radiated energy. This N^{13} nucleus ejects a positron, or positive electron, to become stable C^{13}. The C^{13} absorbs a second proton and becomes ordinary nitrogen N^{14} and ejects more radiation. The N^{14}

riddle of the stars

(*Continued from page 13*)

absorbs a third proton and becomes unstable oxygen O^{15} with the liberation of more radiated energy. The O^{15} decays into N^{15} and another positron, and the N^{15} absorbs a proton, ejects an alpha particle (He^4), and leaves as a residue the original carbon C^{12}. The nuclear reactions are summarized below:

(*a*) ${}_6C^{12} + {}_1H' \rightarrow {}_7N^{13} + h\nu$

(*b*) ${}_7N^{13} \rightarrow {}_6C^{13} + C^+$

(*c*) ${}_6C^{13} + {}_1H' \rightarrow {}_7N^{14} + h\nu$

(*d*) ${}_7N^{14} + {}_1H' \rightarrow {}_8O^{15} + h\nu$

(*e*) ${}_8O^{15} \rightarrow {}_7N^{15} + e^+$

(*f*) ${}_7N^{15} + {}_1H' \rightarrow {}_2He^4 + {}_6C^{12}$

("$h\nu$" means energy is radiated)

In the sun the total cycle takes about five million years to be completed. This gives a reasonable answer of about one hundred billion years before the sun's energy is exhausted. This figure is at least possible, unlike that obtained from the gravitational contraction hypothesis alone.

However, the rate of the reaction increases sharply with the temperature. Furthermore, the temperature is a steep function of the mass, just as we would expect from the gravitational contraction hypothesis. These two relations correlate the rate of radiation, or luminosity, with the mass, giving rise to a fundamental law of astronomy known as the Mass-Luminosity Relation. The law was derived theoretically by Eddington on the assumption that stellar material is a perfect gas. Observational evidence confirms Eddington's calculations for ordinary stars like our sun. Some exceptions are: certain very dense stars, whose material is hardly a perfect gas; the huge but cool stars known as the "Red Giants" because of the color of their light; and the so-called "cepheid variables," whose luminosity and volume vary regularly with time. But more about the "freaks" later.

The amazing thing about Eddington's calculations is that they have any validity at all. Terrestrial gases fail to behave like perfect gas at pressures only a millionth of that of stellar interiors. The "perfect gases" of the stars are often ten times as dense as mercury!

The difference in physical composition of ordinary and superheated matter accounts for the applicability of the perfect gas law. The "size" of an atom is determined by the distance of the outer shell of electrons from the nucleus. Since the star does not contain ordinary atoms but highly charged ions with the outer electronic shells stripped off, stellar particles are much smaller than the corresponding terrestrial atoms. This immediately explains how stellar material can be so dense. An iron atom, for example, would have lost all but the two inner electrons in a star and would have a volume of only a millionth of that of the original atom. Since the deviation from the perfect gas laws are mainly due to the finite size of atoms, stellar material behaves like a terrestrial gas would at a small fraction of the pressure.

Gravitational collapse and the carbon-nitrogen cycle can be tied together in a reasonable theory. The gravitational collapse of a gas occurs until a temperature high enough to start the carbon-nitrogen cycle is reached. It seems that radiation has a much harder time getting through helium than hydrogen. Hence, as the hydrogen supply is converted to helium, the radiation density builds up in the center of the star, raising the temperature. This means that a great deal more energy is produced (the C-N cycle is very temperature dependent). A curious situation arises; the more fuel the star uses, the hotter it gets and the faster it burns more fuel. Also, the surface temperature increases as the star ages. We

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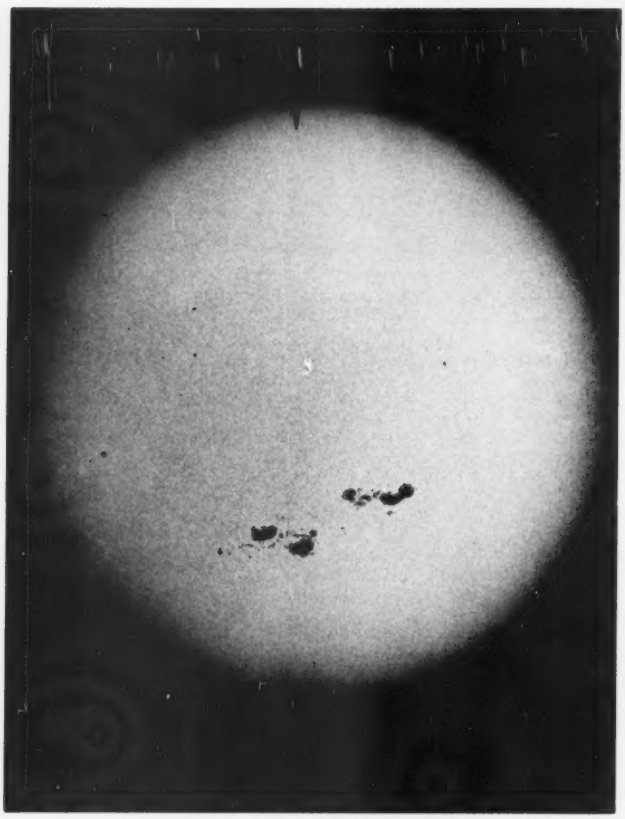

The surface of the sun under excellent conditions, showing large sunspots and the fine structure of its surface. The sunspots are actually extremely bright, but in comparison with the even more luminous gases which surround them, they seem to be almost black.

radioactive milk?

Fission Products Put to Use

By John R. Schrieffer, '53

The advent of the atomic era is posing many pressing problems. One of them is the disposing of the by-products in a nuclear fission (splitting) process. The realization that these radioactive products have vast industrial uses has recently created great interest in fields of science and engineering. Development of their industrial uses will thus serve a twofold purpose. First, the new processes which have been proposed will aid manufacturers in cutting costs and will present a more desirable product to the consumer. Second, this will be an effective means of disposing the hazardous, radioactive materials.

Fission products will be industrially valuable because of their radiation rather than physical or chemical properties. For this reason, semi-refined products appear to have the greatest industrial use. Medium or high activity will be desirable so that a reasonable intensity of radiation may be had from a fairly small source. The necessity of a small source arises from the popularly known need for shielding to reduce the danger of physical harm to factory workers. With these factors in mind we may appreciate the suggested uses of the fission products.

The most outstanding application of the radiation is for sterilization and pasteurization purposes. The fact has been established that living organisms can be killed by radiation. The most important quality of this type of sterilization is that it does not raise the temperature of the bombarded material; many materials which require such sterilization are heat sensitive and temperature increases cause detrimental effects. Pharmaceutical and medical supply manufacturers can use this means of sterilization on penicillin and other antibodies as well as on baby products and adhesive bandages. The food industries show equal interest in the radioactive qualities. Canned hams, milk, dried eggs and prepared ice cream mixes appear to be likely candidates for radiation sterilization. Surface pasteurization of pre-packaged fresh fruits and vegetables will also present a high market for the fission products. Sterilization of beer is an interesting venture for future research.

A second primary use of the radiation would be for insect and fungus control. Elimination of insect contamination of packaged flour and grain products will be a victory for the housewife. Control of weevils and other insect pests in stored seeds, corn and rye will win the farmers' confidence. Coating underwater cables may effectively combat mold and fungus growth. Other interesting suggestions are: the introduction of a small amount of the fission products in a fluorescent tube to lower starting voltage requirements and starting time by producing permanent ionization of the gas. Another is for tracers in air pollution studies and testing contacts on switches. The uses appear to take on unlimited proportions.

The technical considerations for implementation of these proposed uses are in general complex. In order to appreciate the problems that arise in such processes, one must understand the source of the radiation. Upon the basis of this knowledge, one may answer the questions of what type of radiation is emitted, what is the energy of the radiation, what is the decay rate of the material, and how much radiation is emitted by a given weight of material?

In the production of Plutonium 239, two naturally occurring isotopes of uranium are used, U-235 and U-238. When the lighter isotope is bombarded with slow neutrons, a fission or splitting process takes place. The products of this fission are in general a number of neutrons and two nuclei called fission products. These fission products consist of isotopes of elements in the atomic weight range of 72 to 162. Figure 1 shows the yield of these fission product chains as a function of mass. Radioactive fission products are unstable atoms that spontaneously emit beta particles and thus change from one element to another. The process of emission of the beta particle is essentially transforming a neutron into a proton and radiating an electron or a beta particle and a neutrino. The latter particle is of little importance to us. It does, however, share the total energy of decay with the beta particle and thus effectively robs us of valuable kinetic energy with which we will bombard our target, whether it be a can of milk or a beef steak.

The emission of the beta particle leaves the nucleus in an excited state and to reach its "normal" or "ground" state it emits one or more gamma rays. This form of

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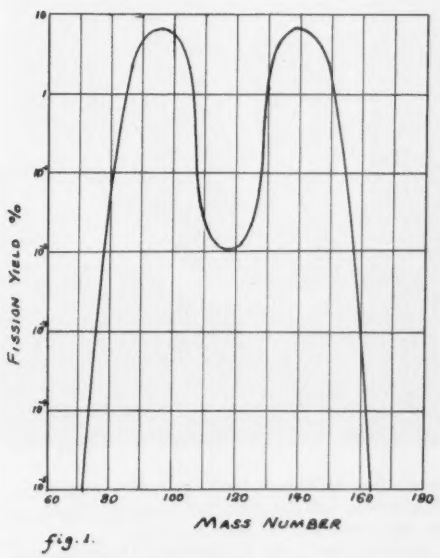

fig. 1.

The composition of fission products, the "nuclear ash" left by splitting of heavy nuclei by neutrons, as a function of mass number of the product.

The Best Living Group at Tech?

. . . dormitories!

By David L. Klepper, '53

Despite the existence of fraternities and rooming houses, a majority of the incoming freshman class is going to live at East Campus. You may find specific details concerning the accommodations existing here in the Institute Catalogue; on your tours of other living groups you will hear of much that is supposedly wrong with dormitory living. This article is an attempt to tell you why some of us like dormitories.

Important are the dorms' definite physical advantages. Their proximity to the Institute presents an ever present encouragement to join any of the extra-curricular activities that serve to broaden your college experience. Less travel time means more time to spend with these activities, without sacrificing time for studying. Dorm residents participate in all varsity sports, for instance, and many are active in student government.

The dormitories are well represented in intramural sports also; however, here, as in all M. I. T. athletics, the emphasis is on participation rather than just winning games. Perhaps the most popular athletic facility belonging to the residents of East Campus is the pool table. Located in the old Ware Dormitory Lounge, it has been a center of attraction ever since it was purchased this past spring. Mention must also be made of the ping-pong tables which are available to all dormitory men.

Important to dormitory life are the various lounges throughout the dormitory system. During the week many of the more important Institute activities hold their meetings, after school, in these lounges; later in the evening they become valuable places for holding bull sessions without disturbing the studying of room mates. On week ends they are signed out for parties and informal dances. They always provide a spot to sit and relax and read the latest periodicals or listen to the music provided by the FM tuner or the record player. Occasionally the lounges are used for dormitory-sponsored functions, parties, and dances.

Anyone really interested in classical music will find the excellent Music Library close by in Hayden Library. Any student may select from a very large collection records which he may play on players located in small rooms. Its proximity to the dormitories encourages the extensive use made of all Library facilities by dorm men.

Located conveniently near the East Campus dorms is the Walker Memorial Building. Many important activities have their quarters here, including the three publications and the Technology Christian Association, the school service organization. Formal and informal dances are held in the large ballroom on the main floor, by day a cafeteria.

Much has been said by students about dormitory dining service. All first-year students residing in any M. I. T. dormitory must pay for weekday contract feeding at one Institute cafeteria. I, personally, have always been against any compulsory contract feeding

(*Continued on page 57*)

(Above) A practical problem in higher mathematics: where will the darn ball bounce? Some of the dormitory pool experts in action.

(Left) This dorm room just oozes with that artistic feeling, and two critics seem to be expressing their professional opinion of the masterpiece. The rifle is not usually needed for self-protection.

. . . fraternities!

By John Mathis, '53

What will we get from our four years at Tech? A good education, certainly. That might be all; the rest is up to us. But we all would like to be human beings also, who can see beyond the end of our slide rules. We are charged with getting as much out of our college years as we can, not just academically but in every phase of living.

We all are proud of our country. And we would regard an insult to a member of our family as an insult to ourselves. Why? Because, as members of a group — family, school, nation, or otherwise — we take on the common goals of the group. We identify ourselves with it and are proud of it. Almost all of our pleasure comes to us from our group associations. This is especially true in college; the feeling of "belonging," of sharing work and fun with others, is about the greatest pleasure that college can provide. A Techman can be a member of one of several living groups; his own family, the dormitories, or perhaps an apartment house. But many feel that the best way to get the most out of their stay at Tech is to join a fraternity.

"Fraternity: the condition of brotherhood." So a dictionary defines the word. But probably few of the members of fraternities at Tech can say exactly what their organization means to them. Primarily it represents a group of fellows who have shared most of their experiences at Tech. They know each other intimately and like each other. Of course, the average fraternity man has many friends and interests outside of his own organization. But primarily he feels a loyalty towards the men whom he has accepted as brothers. And, equally important, he knows that they feel this same loyalty towards him. And the fraternity man is firmly convinced that no other living group at Tech can provide such close and lasting ties of friendship for the average fellow as the fraternity system does.

The most obvious difference between fraternities and other living groups is one of size. In a fraternity, one is not restricted socially to one or two fellows, but still can really know each member of the group personally. Of course a knowledge of an individual's personality, habits, and problems is essential to real friendship. And from thirty to sixty fellows is about the largest group wherein each member can know all of the others well. The sense of "personal belonging" is the basis for the warm feeling a fraternity man always has for his brothers at college and the organization that brought them together.

Naturally there are many activities which the average fraternity man is interested in, and his "house" is normally the center of most of them. First of all, it is the scene of most of his social activities; every house holds private, informal dances and parties frequently. The House sponsors beach parties and hay rides. At least once during each year the House has a "bid" party to which each member can invite his outside friends. Of course his friends who belong to other fraternities return his invitation whenever their House has such a party. This system of exchanging invitations solidifies his friendships outside of his own House. He can bring his girl out to the House just as he would at his own home. Furthermore, he is encouraged to become socially well-rounded by his brothers, who provide incentives for the more retiring men to develop social initiative. This encouragement would be very beneficial to many students at Tech.

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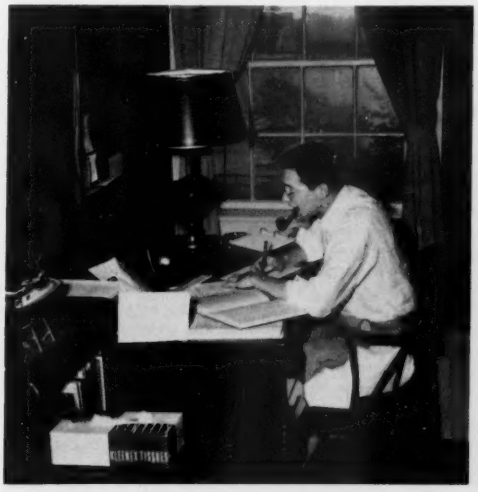


(Above) A fraternity resident looking like he is hard at work, just to prove that it can be done.

(Right) One of the innumerable "bull sessions" which crop up at the fraternity house.

robot chess

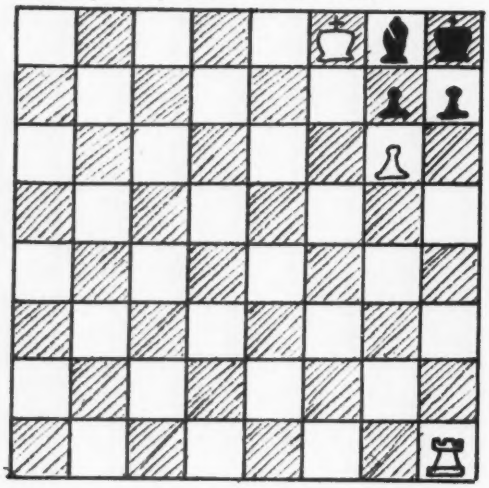
By D. G. Prinz

The age-old dream of machines playing games of strategy, like draughts or chess — and playing them well enough to beat human opponents — has recently been revived for two reasons. One is the realization that problems of economics can be analyzed by means of logical structures similar to those implied in games of strategy. This seems to lift the interest in game-playing machines out of the realm of mere entertainment into the class of respectable scientific research; if machines can be made to play games, they should be able to solve economic problems of similar structure.

The second reason is the advent of the "electronic brains" or, to give them their proper name, universal high speed electronic digital computers. The emphasis here is on the "universal." The same machine can be made to solve a problem in aircraft design in the morning, compute optical lens systems in the afternoon and work out wage lists in the evening. You can make it do all this without any alterations in its design, without plugging in new connections, simply by providing it with suitable information, usually contained on a punched teleprinter tape or similar device. The problem is no longer "making a machine to play chess" but rather "making a machine play chess." You do not have to be an inventor or engineer; all you need is paper, pencil and patience. You also need access to an existing electronic computer, including the apparatus for converting your notes into a punched paper tape, and a knowledge of the "code" used by the machine, i.e., the system for writing down information in such a form that the machine may understand and carry out your instructions.

The complete list of instructions (or "orders" or "commands") required for any particular problem is called a "program," and the technique of designing programs, or of "teaching" the machine what to do, is known as "programming." Subsequences of instructions in a program are often called "routines."

Fig. 1. A simple chess problem that took the machine described in the article fifteen minutes to solve (White to move and mate in two moves). You can probably beat the machine's time.



A chess problem, as every player knows, is the problem of finding a move, the "key move," which will mate the opponent, irrespective of his replies, in a given number of further moves. A simple experiment which has been set up in Manchester, England, demonstrates the basic problems of chess machines. Only the simplest case, the "mate in two," has been treated, and even so, some of the moves permitted by the rules of chess (double pawn moves, castling and the exchange of a pawn for a piece on reaching the last row) have been excluded to make the program as simple as possible. Finally, the possibility of a stale-mate was admitted as a solution.

To anticipate the result of the experiment, it has turned out that the machine, when provided with the program to be described, can make chess moves and find the solution of chess problems within the limits stated above; but it does so much more slowly than a human chess player.

One reason is that the machine is built to carry out arithmetic operations, and the moves on the chess board have to be broken down into a series of such operations before the machine can deal with them. If you are told that the white King is in one corner of the chess board, and that the black King is in another corner, the remainder of the board being empty, you know at once that neither King is in check. But the machine is in the position of a man who has to carry out an arithmetic operation to find which square to examine next and, having arrived there, finds instead of a chessman a piece of paper telling him which arithmetic operations this chessman is allowed to perform in order to reach other squares. Altogether, several hundred operations may be needed to find out whether or not the King is in check, and even at electronic speeds the whole process may take an appreciable fraction of a second.

Another reason is that the present program does not eliminate unlikely moves: the machine is forced to investigate every possible move, until the solution is found. Even for a two-mover, the total number may run into several thousand on the average, and will be below a thousand only for particularly simple positions. Since every move has to be followed by a test for legality, it may consume something like 1 or 2 seconds, and the total time required for the solution may be several hours. The extremely simple problem illustrated in Figure 1 took about 15 minutes to solve; most chess players could find the solution in less time than this.

Since the rules of chess usually impose a time limit, the machine would stand no chance of winning a game against a human player; but it could (with minor modifications to the program) be made to play a game against another machine, or against itself. The possibility must, of course, not be excluded that by refined programming, by the use of faster machines, or both, a superior game played by a universal electronic computer may finally be realized, not to mention the possibilities of special

machines built for the purpose of playing chess only.

Before going into a detailed description of the program, it will be necessary to state briefly the essential features of the electronic computer.

The nucleus of the machine is a store in which patterns, consisting of two different units (like the dots and dashes of the Morse code), can be kept. These patterns can be interpreted as numbers, letters or other pieces of information. The exact correspondence does not matter here. The non-mathematical reader may think of the Morse code, the teleprinter code, or the Braille script. For the mathematical reader it may be sufficient to hint at the binary number system, a form of digital representation in which the only digits used are 0 and 1. Neither is the actual form of storage important at this point. Suffice it to mention that the Manchester machine employs two forms of storage, one using magnetized elements on the surface of a rotating drum (similar in principle to magnetic tape or wire recording), the other using electrical charges on the screens of cathode ray tubes, similar to those contained in television receivers. The punched tape containing the original information supplied to the machine may be regarded as an additional, external store.

In the cathode ray or "electronic" store the information is arranged in successive lines, each line containing either a number or an instruction. The lines themselves are numbered consecutively and the number of a line is often called its "address." This address or number of a line must be distinguished from the number contained in the line.

An instruction consists of two parts, the address and the function part. When the machine "reads" an instruction, it rearranges its internal connections just as an automatic telephone exchange connects you to another subscriber when you supply information by dialing a telephone number. More specifically, the machine will be "connected" to the line the address of which forms the address part of the instruction, and it will then either carry out an operation on the number contained in this line, or send the result of a previous operation to this line. Thus, an instruction of the form "53,A" may be interpreted to mean "add the number standing in line No. 53 into the addition register," and the instruction "54,B" may mean "send the contents of the addition register to line No. 54." The time required to read and carry out an instruction is different for different computers; for the Manchester machine it is about one thousandth of a second.

Under the influence of a "control unit" the machine goes normally through the instructions in their natural sequence and obeys them one by one. However, amongst these instructions there are some which in turn react on the control unit; their effect is to interrupt the normal sequence, causing the machine to "jump" to some other instruction in the store. In particular, it is possible to go back to a previous instruction so that the same cycle of instructions is repeated over and over again. By making these "control transfer instructions" dependent on certain arithmetic conditions it is possible to leave this "loop" of repeated cycles after a specified number of times, or when a specified result has been obtained.

Since instructions are kept in the store together with numbers, they can themselves become the object of arithmetic operations. In particular, it is possible to modify their address part. Thus, by adding 1 to the address part, the instruction "53,A" can be altered to "54,A." This facility is quite fundamental for the applicability of machines of this type. Suppose we wanted to add together the numbers in lines 100, 101, 102 . . . up to, say, 199. If we had to write down all the instructions 100,A, 101,A . . . 199,A explicitly and punch them out, there would not be much point in having a machine obeying these instructions at a rate of a thousand per second. Instead, we only write "100,A," followed by instructions adding 1 into the address part, and a control transfer instruction leading back to the beginning and so conditioned that the machine stops (or goes to some other sequence) when "199,A" is reached.

What this means is that the machine can "look up" a table or directory just as we can find the logarithm of a given number from a mathematical table, or the telephone number of a given person in the directory.

It should be mentioned here that the Manchester machine has a special facility for curtailing this process of modifying instructions. By making use of this facility, or by using conditional control transfer instructions, it is possible to make the machine go to different subsequences according to the number contained in a specified storage line. Thus, by allocating different numbers to the six chessmen (e.g. King = 2, Knight = 3), the machine can be made to enter a sequence dealing with King's moves when a certain storage line contains 2, and to enter a sequence dealing with Knight's moves when this line contains 3.

It will now be possible to describe the essential features of the program by means of lists or tables, consisting of pieces of information contained in successive store lines. The machine goes through these lists under the control of "counters," certain numbers (kept in other storage lines) which are increased by 1 or 2 at appropriate stages in the program.

To describe the first of these lists, imagine all the thirty-two pieces numbered consecutively, e.g., from 0 to 7 for the eight white Pawns; 8,9 for the white Knights; 10,11 for the white Bishops; 12,13 for the white Rooks; 14,15 for the white King and Queen; the black pieces are similarly numbered from 16 to 31. The number thus allocated to each piece is called the "piece

(*Continued on page 59*)

Fig. 2. How the machine denotes the positions on the board. The fringing rows of numbers are necessary in order to tell the machine where the edge of the board is.

90	91	92	93	94	95	96	97	98	99
80	81	82	83	84	85	86	87	88	89
70	71	72	73	74	75	76	77	78	79
60	61	62	63	64	65	66	67	68	69
50	51	52	53	54	55	56	57	58	59
40	41	42	43	44	45	46	47	48	49
30	31	32	33	34	35	36	37	38	39
20	21	22	23	24	25	26	27	28	29
10	11	12	13	14	15	16	17	18	19
0	1	2	3	4	5	6	7	8	9

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605 North Michigan Avenue, Chicago

from the editor's notebook

Sure Cure for the Bookworm Blues.....

There are some students at Tech who feel that the Institute is primarily one continuous "grind." And it probably is for them. Yet others, who perhaps study as much or more, are not burdened by their academic load. The difference? In most cases, it does not lie in varying methods of study; rather, in different means of loafing! To sum up the difference in one word: activities.

When there is all too little leisure time available, it must be put to good use. And, when all is said and done, the best way to spend leisure time is to do something that is interesting. That is exactly where student activities fit into the picture.

There are activities which suit almost any conceivable taste, and which enable their members to have a darn good time while actually getting valuable training in running an organization. And there are plenty of positions available which involve considerable responsibility for those who are willing to undertake it. No one should feel that he does not have a chance to rise to a high position; if he puts enough effort in, he is bound to find it rewarded. One of the largest and most influential organizations on the campus last year was discreetly trying to find a *volunteer* to fill one of its managerial positions! It doesn't take a genius to rise to the top; whoever will give his time gets the best positions.

Which activity is best? The most interesting! Naturally, I happen to be most familiar with the opportunities available at *T. E. N.* Suppose you happen to be interested in seeing your work appear in a reasonably serious magazine. Drop down to the *T. E. N.* office in the basement of Walker any afternoon after five and meet some of the magazine's staff. There is work available in every department of the magazine's operation; writing, advertising, sales, circulation, make-up, and others. The top men can come from any department. A roughly similar situation exists in most other student organizations.

Real participation in an activity always provides at least one thing: a lot of fun. There are always meetings and parties which the activity holds. These enable each member to get acquainted with other fellows of similar interests and, very often, with Institute faculty members. Also, there is a pride in the organization which is developed by dint of much hard work. Furthermore, there is a certain amount of prestige which accompanies any of the responsible student jobs on the campus.

It is never too late to join an activity, even for upperclassmen. Start off with the intention of putting a little effort into the project in exchange for the many benefits which you will receive. Naturally I hope you pick *T. E. N.* But if you aren't in our office, at least be in somebody's.

J. S. M.

New RCA Victor record changer
—easiest to play at all three speeds!

THE CENTER IS THE SECRET:
Just slip on the large center spindle to play "45" records *automatically*. Slip it off, and play records at other speeds.
Permanent spindle and changer play stacks of 33⅓ or 78 rpm records automatically.
A flick of the finger and you have the right needle to play 45, 33⅓, or 78 rpm records.
Fingertip control of speeds (78, 33⅓, 45) and one control for *On*, *Off*, or *Reject*.

World's simplest 3-speed changer, this versatile Victrola combines new playing ease with the finest reproduction of sound. And it changes "45" rpm records *correctly*, on the same turntable used for other speeds.

Key to this advance is RCA Victor's *slip-on* "45" spindle, which fits over the permanent spindle and locks in place. No plugs or extra gadgets. Simply stack your "45" records on this fine instrument, and play up to fourteen of them—at the twist of a knob. Then, whenever you wish, remove the "45" spindle, flick the needle and speed controls, and the same Victrola changer will play records automatically at 33⅓ or 78 rpm.

More than a year of research and engineering went into this changer—further evidence of the leadership which assures you finer performance in any product or service of RCA and RCA Victor.

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- Advanced development and design of AM and FM broadcast transmitters, R-F induction heating, mobile communications equipment, relay systems.
- Design of component parts such as coils, loudspeakers, capacitors.
- Development and design of new recording and producing methods.
- Design of receiving, power, cathode ray, gas and photo tubes.

Write today to College Relations Division, RCA Victor, Camden, New Jersey. **Also many opportunities for Mechanical and Chemical Engineers and Physicists.**

From the February 1936 Issue of T. E. N.

ruts of stagnation

By Prof. F. Alexander Magoun

"The only difference between a rut and a grave is in their dimensions," said Helen Glasgow, and she was almost right. She forgot that men in a rut often prove a stultifying bondage to others, whereas the cold, dead hand seldom reaches up from the grave to preserve the *status quo* for very long. But the rut and the grave are at least alike in that both are occupied by people who have ceased to learn and possess no ability to think along new lines.

"The old fossil!" said a young lad seeking to describe, with a terse and elegant phrase, someone many years his senior. "No," objected the boy's mother. "A fossil was alive once!"

Because college boys are all very much alive with an unrest that is almost infectious; because they are pardonably preoccupied with such mighty affairs as love, the befuddled hopes of a great career, and the pungent contradiction of science vs. religion — because of these things, they give little thought to the lurking danger of stagnation. Of the grave itself they think little subjectively and say less; of that living grave, the rut, they think introspectively not at all. Uncle Julius may have been an old fossil, but petrifaction already creeping through their own veins? Never!

Wherever a long period of habit formation has taken place with no fundamental change and no improvement, stagnation is inevitable.

Where then, are the college boy's vulnerable areas?

To begin with, by the time he earns his cap and gown he is likely to be pretty well satisfied with himself; not overly satisfied with this laggard world perhaps, but satisfied with himself. "The greatest cause of stagnation," said Elliott Dunlap Smith in accents which compel deep thought, "is self-satisfaction." Because he possesses a sheepskin which attests the fact that he belongs to the select company of intellectual men; because he has studied only when and as directed — a stimulus entirely lacking after graduation — the college man is in grave danger of thinking that he knows it all.

The great work of the world has been done by men who were entirely dissatisfied with what they had accomplished and what they knew; men who succeeded in thinking out old situations from unconventional points of view; men whose intellectual patterns were not in ruts despite the difficulties we all feel when our thoughts try to cross a frontier. There was Archimedes, for example, discovering a new and far more reaching physical relationship instead of shouting impatiently for a slave to mop up the bath water; Isaac Newton, stimulated to profound reflection by the thump of an overripe apple (the same which got Adam and Eve into trouble and which had beat upon the numb brains of a thousand fulminating yokels before Sir Isaac had asked "Why" instead of exclaiming "Damn!"); Albert Einstein, unwilling to accept Newton as final despite the fact that the cream of gravitation truth had probably been skimmed before.

None of these men had stagnated into merely thinking what others had thought before them. Where other minds followed the time-worn ruts, their minds were pioneering untrodden ways.

In short, the great source of stagnation, as indeed of most weakness, is in the mind. From this point of view it has always seemed to me one of Homer's major psychological triumphs that he had Thetis dip the child Achilles into the waters of the River Styx in such a way that the boy's vulnerable point was in his heel, not his head. Not all present-day football-conscious mothers would have been so wise.

Stagnation comes quickest to the man whose habit patterns do not change. This is easy to see when applied to the draftsman who leans over a drawing table, to the technical assistant making endless identical analyses of multitudinous samples of water, to the misguided though strenuously Christian clergyman who uses the same barrel of sermons over and over again. It is less obvious but equally applicable to the engineer, the scientist, lawyer, physician, executive, or what-have-you who fails to provide regular, inescapable checks to shake himself out of the rut which threatens to overwhelm and swallow him so comfortingly.

How?

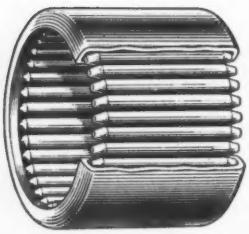
To begin with, write an annual report on yourself intended for no other scrutiny but your own. Let it include a financial statement — with comparisons to previous years — of earnings, savings, and distribution of expenditures. Let it list the magazines and books you have read during the year with a careful estimate of *how that reading had changed your opinions or enlarged our mental horizon.* Let it investigate what things have made you very happy and what very angry and why. What original ideas have you had? What professional papers have you written? Let your report dwell coldly upon such questions as "What have I gained?" "What have I given?" "What have been my dilemmas?" Dilemmas vary all the way from, "Shall I shave every day or every other day?" to "How can I sift the truth from the propaganda that reaches my ears every day and what should be my reaction to it?"

Make a personal five-year plan and then check on its accomplishment. If, over a period of years, you will write such an annual report, by examining a series of them it is easy to see whether your progress has been philosophical, financial, intellectual, and emotional, or only financial. If it fails, analyze the failure. If you want to stagnate, stagnate, but do not go through life with a soul toothache that your talents were never half appreciated.

We Americans are so prone to measure progress only in terms of money. How much wiser it would be to think in terms of time. Stephen Foster died in the Bellevue Hospital possessing the altogether sufficient and magnificent sum of $1.25. But how well he used his time to produce an imperishable stream of lyric beauty which will outlive the gold piles of those already forgotten men who in the 1850's would have written a

(*Continued on page 65*)

The Torrington Needle Bearing needs little space—saves time in assembly



The Torrington Needle Bearing is a completely self-contained unit consisting of a full complement of small diameter rollers and a single retaining shell. This unit design and construction greatly simplify handling and speed assembly, and help reduce the size and weight of related parts.

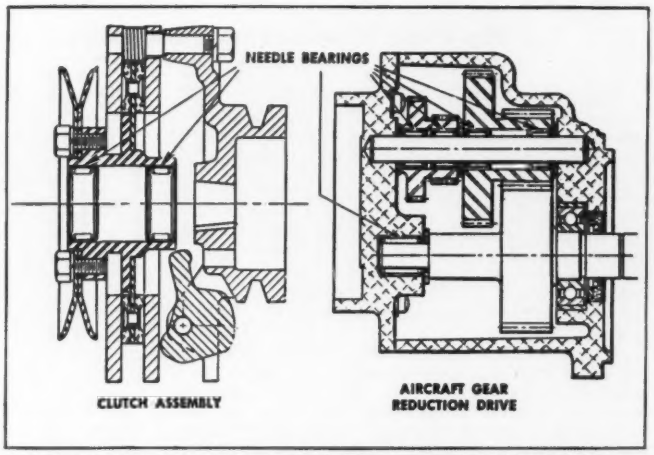
High Load Capacity in Small Space

Because the many rollers distribute loads over a large contact surface, a Needle Bearing has a very high load capacity in relation to its size. In fact, the Torrington Needle Bearing has a higher rated radial load capacity than any other type of anti-friction bearing of comparable outside diameter. This not only permits the use of a smaller, lighter bearing for a given load, but also allows reductions in the size and weight of housings and other related components. The Needle Bearing's large inside diameter permits larger shafts to be used in cramped quarters, an important factor in many designs.

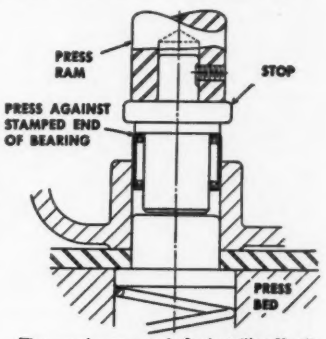
Installation Simplified

The installation of Torrington Needle Bearings is fast and easy. The housing bore is simply machined to proper diameter. The bearing is then pressed into this housing. An arbor press is normally used for this operation. No spacers or retainers are needed to keep the bearing in place. An accurately made shaft is required, of course, as it serves as the inner race in most cases and must be hardened and ground to correct size. For applications where an unhardened shaft is desired or necessary, inner races can be furnished for all Needle Bearings.

These advantages make Torrington Needle Bearings ideal for applications where space or weight is at a premium, or where mass production methods necessitate the use of a bearing that is as easy as possible to handle and install.



Typical installations of Torrington Needle Bearings are characterized by simplicity of design. Needle Bearings are made for shafts as small as 5/32" up to those as large as 7¼".



The use of proper tools for installing Needle Bearings speeds up assembly. The arbor press tools above are ideal.

Other features of Torrington Needle Bearings will be covered in other advertisements in this series. For additional information regarding Needle Bearings, please contact our engineering department.

THE TORRINGTON COMPANY
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TORRINGTON NEEDLE BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS

stained glass windows

Modern Work in a Medieval Art

By J. Wellington Lanesborough, '53

A stained glass window is composed of small pieces of white and colored glass held firmly together by strips of grooved lead soldered at the joints. It must be clearly understood that the color, the real glory of stained glass, is not painted on the glass, but is produced when the glass is manufactured. Various metallic oxides mixed with the glass while it is in a molten state produce the coloring. It can be readily seen that whenever a change in color is desired in a window, a separate piece of glass must be cut. With few exceptions, the color pervades the whole piece of glass, and its unequal thickness gives the various shading. "Flashed" glass is white glass covered with a layer of colored glass. Beautiful effects can be obtained by eating away parts of the colored glass with hydrofluoric acid. The only paint used in the making of a window is an opaque, vitrifiable pigment, used merely to delineate form and detail. No actual color is ever painted on the glass, except a "stain", an oxide of silver. White glass, with the use of this stain, produces a beautiful transparent yellow, varying in the tint from a light yellow to a rich orange, after it has been fired in a kiln.

Although modern manufacturing assists the present-day craftsmen, the same processes are employed as in the Middle Ages. In place of moulding the lead by hand, the modern workers buy it manufactured in various sizes and shapes. Gas and electricity now take the place of charcoal for heating the soldering irons, while diamond or steel wheels are used to cut the glass in place of the primitive method of drawing a red hot iron across the glass and with sufficient hand pressure breaking the glass in two.

Like other technical arts, the conception and development of stained glass necessitates the employment of trained craftsmen. As in medieval days, the window designer should be a thorough craftsman, capable of not only designing, but painting on the glass and if necessary, leading the window.

When a glass designer and craftsman is commissioned to make a window, he should first of all, whenever possible, see the building his window is to adorn and study very carefully its lighting conditions and architectural surroundings. Too many of our churches have already been filled with windows in which style and periods have been sadly mixed. Now, thanks to many of our architects, even the so-called commercial glass men must keep within certain limitations.

The preliminary design in water color, drawn to scale, serves as a working model for the artist and gives to the client an idea of the appearance of the completed window. After the design has been approved, the next step is to draw the "cartoon", or full-sized drawing in black and white. This drawing is the actual size of the completed window and all details, including lead lines, Tee bars, and saddle bars (of which mention will be made later) are carefully drawn. The cut-line drawing and pattern drawing are traced from the cartoon. These drawings show very clearly the various shapes and sizes of the individual pieces of glass, and to offset any future difficulties, the shapes are numbered.

The pattern drawing is cut into the individual patterns for the glass with a double-bladed knife. This knife cuts out a thin strip of paper from between each pattern, which allows for the heart of the lead to fit between each piece of glass. The patterns are placed upon the cut-line drawing, and with the water-color design as a guide, the colors are selected and with a diamond or steel wheel, the glass is cut around the patterns.

Then the artist places the pieces of glass upon the cartoon and traces all drawing lines and details on the glass with the vitrifiable pigment mentioned before. For tracing, varnish and turpentine are usually mixed with pigment, although certain workers prefer mixing water with the color, which is either brown or black. To prevent any possibility of losing the trace lines in the next process, the glass should be fired until the painted lines actually become a part of the glass. For the ensuing process of painting, it is necessary to set the glass in place before a window. A large plate glass easel is therefore placed on a flat bench, with the cut-line drawing placed beneath to aid in locating the pieces of glass. A small space must separate the pieces of glass, for later on the heart of the lead fills this space. Melted wax is dropped into these spaces at intervals, holding the glass firmly on the easel. By placing the easel in an upright position before a window, the glass is seen as a whole for the first time, and any color changes desired are made. Since in the finished window, black lead lines will take the place of the brilliant light now visible between the pieces of glass, the spaces are filled in with black paint (or should be by any craftsman who is sincere in his effort to reproduce his design accurately).

Each piece of glass is then covered with a mat of the same pigment used in tracing, with gum arabic as the adhesive medium and water to thin the color. When the paint is dry, lights are taken out with a bristle brush or with the finger and palm of the hand, leaving only enough paint to give to the glass an interesting texture, and which, if well done, will mellow the color of the glass without causing loss of any of its particular gem-like brilliance. The painter must take into consideration the distance from which the window will be seen and gauge the texture accordingly. Light plays many tricks when shining through glass. For example, a clerestory window must be painted boldly, with the use of heavy trace lines, in order to get a result that is strong in design.

With the painting completed, the pieces of glass are removed from the easel and fired so that the paint becomes a part of the glass permanently. Again the glass must be waxed upon the easel and painted for the second time, for the intense heat in the kiln has probably reduced the paint and in some cases burned it almost entirely away. Even a third painting is not infrequent, and special firing for stain gives the most satisfactory results.

The glass is now ready to be put together with strips of flexible lead the shape of an "H". The cut-line drawing is laid on the glazing bench; a straight edge of wood is nailed to the base and another along the side

(*Continued on page 66*)

technologist as man and citizen

(*Continued from page 8*)

mammoth industrial organizations in and near the cities, relinquished to a vastly enlarged and centralized government an ever-growing responsibility for our jobs, our food, our housing, our medical care, our education, and our keep in our old age. A bigger, more complicated machine; a new scheme worked out by a team of specialists; a new governmental bureau; or a new governmental service supported by another hidden tax is somehow assumed to be the solution to any problem. Meanwhile, and perhaps most important in understanding our questions, human beings have been crowded together in such large cities or organizations that they have lost their identity as individuals and instead have become numbers on a machine, cards in a file, or members of a group or class who can be treated as a group without regard for individual differences. We have many material luxuries available to us today but sense that we have lost our individuality in a class or group; it is not hard to understand why we have become materialistic. Many of us have fallen into the trap of feeling, "There is nothing *I* can do about it; I've got to go along with the rest and meanwhile get for myself and mine all I can get."

The effect of the scientific revolution on society at large is clearly reflected in our colleges and universities, particularly the larger ones. Let us use M. I. T. as an example of such schools. Once it was a comparatively small institution in which, generally speaking, everyone knew everyone else. It was therefore truly a community of scholars. Now it is a large institution where even the Faculty and staff do not know each other intimately. As in industry, altogether too many students can pass through the Institute, particularly in the early years, with no intimate contact with the Faculty and staff, and therefore the feeling that they are nothing but cards in the file or numbers on a machine. Lacking this intimate personal contact, the student fails to have transmitted to him the ideals and spirit of the institution and, therefore, instead of building a unique sense of belonging and resultant personal responsibility for cherishing and preserving these standards, he feels himself a member of a large, impersonal group for whom decisions are made by another distant group ensconced in power and not understanding the problems and experiences of the individual student. And so, like the man in large industry or in the large city, the student feels, "There is nothing *I* can do about it; I've got to go along through school for a degree and to the job for which the degree will be the passkey; meanwhile I'll get for myself and my group all I can get." At the same time, the fields of knowledge having multiplied so fast, the emphasis on specialization having been carried so far, the faculty member also feels caught in a group where specialization and intellectual endeavors are given prime, if not sole importance, both in teaching and personal advancement. His salvation, therefore, lies in following this path, finding what fullness of life he can away from the Institute, and leaving to the administration or another group of specialists the responsibility for other phases of individual development and growth of the students. The result tends to be the same for both students and Faculty: there is a lack of cohesiveness, a lack of comradeship, a lack of common ideals, common standards, and common responsibilities.

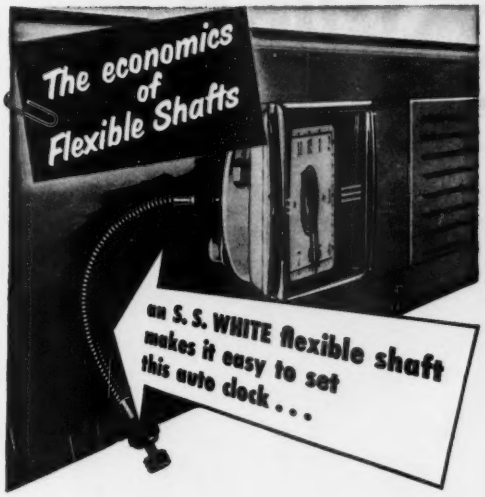
Throughout both our nation and M. I. T. there is a growing understanding of the conditions I have described and an ever expanding determination to do something about it. The feeling at Tech, as I have experienced it in one year, is something like this: "M. I. T. has pioneered in science and technology and realizes what technology has done to society; M. I. T. must continue to pioneer in science, but at the same time must find out how man can live with the conditions he has produced, how the concept of the sacredness and uniqueness of each individual can be preserved, and how man may assume his individual responsibility in the family, the university, industry, and society to retain his individual freedom."

What seem to be the emerging answers to our questions? First, let us look at the broad, overall questions: must we find brand new answers to man's problems? Were our forefathers all wrong? As I work with older men in business, as I talk with older men in the teaching profession, and as I meet the problems young people are confronted with today, I am firmly convinced that we are not seeking brand new answers, that our forefathers were not all wrong. Rather, I feel the answer lies in a restatement of eternal moral, spiritual truths in modern terms and the development of a modern formula by which these eternal truths can be applied to new and modern conditions. I like the mental picture of progress painted by one of my colleagues: molding the stream of truth from the past with the newly discovered truths of our age into one stream which flows into the future, always ready to absorb the waters from new streams of truth and constantly adjusting itself in depth and width to the realities of the stream bed.

I do not believe that the scientific progress made by man in unearthing new truths of nature has in any way changed the nature of man. As I see it, man today, man always in the past, and man always in the future has been, is, and will be a creature of physical, intellectual, emotional, spiritual, and social parts, each part interrelated with every other part. As a living being, which science has not been able to reproduce — and I venture never will reproduce — man has a quality of divinity, a certain something which is in some way connected with a controlling power or being in the universe. It is around this concept that man has developed various religions and it is through those religions, down through the ages, that man has built up what I would call a set of universal moral and spiritual laws. Through a passionate devotion to the ideals inherent in these laws, the United States of America was founded as a country, and in this country our forebears, guided by these same ideals, founded the early schools, colleges, and universities of the country that these ideals might be nourished, kept always bright, and transmitted from generation to generation. Central among these ideals was the concept of the sacredness and uniqueness of each man, woman, and child as a son of God, and the corollary concept of human liberty which it was the bounden duty of each free man to protect, with his life if need be. Government was to be a servant of man, and education was to prepare each generation of men to understand the accumulated wisdom of the ages and to protect man's liberty in his generation. The highest goal of life was to serve one's own God and one's fellow man.

May I suggest that if these same ideals, vividly expressed in modern terms and passionately adopted by the modern mind, became ever more a key motivation in going to college, in planning curricula (yes, even scientific curricula), in training and hiring teachers, in administrative decisions, and in student government, many of the questions the editors asked would be clearly answered or, more realistically speaking, would not have been asked at all. Let us return briefly to the questions asked.

(*Continued on page 27*)



When this automobile clock was designed, its manufacturer had in mind the probability of varied instrument panel locations with the resultant need of an adaptable coupling to the control knob. He chose an S.S.White flexible shaft to do the job. As the illustration shows, this simple hook-up permits both the clock and the control knob to be located in its most advantageous position.

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technologist as man and citizen

(*Continued from page 26*)

Are we training specialists who, as men, are not adequately trained to serve man and society? Without a doubt, the modern educational world must answer in the affirmative, but in so answering today it can say it is honestly trying to correct the situation. At M. I. T., the Faculty is reaffirming the central importance of the individual student, is becoming increasingly concerned with the importance of developing the whole man and increasingly aware of the futility, yes even the danger, of turning out a superbly trained intellect in a man devoid of emotional stability, ability to live and work with his fellow man, and any sense of the moral, spiritual ideals of his school or his country. Similarly, there is increasing concern that the future teacher shall be indoctrinated not only with intellectual standards but with a deep sense of duty and obligation to his students as individuals. Concurrent with these basic convictions, much thought is being given to the environment, course content, and daily schedule that these non-intellectual objectives of education may be adequately served. Plans are almost complete for an auditorium which is visualized as the meeting house of the M. I. T. community — a medium through which I hope the unity of the Institute, our common purposes and our common obligations, may be made clear. As one of the leading scientific institutions of the world, M. I. T. is deeply aware that its graduates must be turned out not only scientifically competent, but prepared to serve in positions of leadership and motivated by a deep desire to serve mankind.

Our second question was this: what is the source and what is the price of freedom? The source of our freedom lies clearly in the past, in our forebears who had a very clear concept of the moral, spiritual laws which operate among free men and a passionate respect for and pride in these ideals; who ordered their daily lives accordingly; who saw to it that their children were indoctrinated with the same ideals; and who then stood ready to sacrifice everything — yes, even their lives — to protect these ideals. The price of freedom is indicated in the source; the price of freedom has always been individual responsibility; without responsibility, no matter what intellectual arguments may be advanced for a particular course of action, freedom becomes license. The mere fact we ask whether the level of conduct at M. I. T. is as high as it should be, indicates we know it is not. Unfortunately, we must say the same thing in the country at large. The answer? Every member of the community must become clear as to the common ideals we serve and then every member of the community must *individually* take the responsibility, with pride and courage in his heart, to live up to those ideals.

We are asked: is it too risky to extend so much freedom? It is much more risky to take it away; the student body has an obligation to its forebears, the alumni of M. I. T., not to forfeit its freedom by a lack of responsibility. The people of Germany forfeited their freedom to Hitler; it turned out to be very risky. No, the answer lies in establishing clearly in the minds of our whole community, in all phases of our activity — academic, athletic, extra-curricular, and social — the standards and ideals which are the heart and soul of M. I. T., and then in holding *each* member of the community personally responsible for living up to these ideals in return for his freedom.

Finally, the third question was: is the role of student

(*Continued on page 43*)

SPRING WIRE

For uniform quality, we're sure this spring wire is the best we've ever made

ROEBLING is about the largest specialty wire manufacturer in America. And with progressively improved facilities and more positive controls we are constantly turning out wires with a higher uniformity of gauge, finish and mechanical properties.

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But I haven't majored in aeronautical engineering

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Those—plus the opportunity Lockheed is offering you—are all you need for a career as an aircraft engineer. In Lockheed's special program for engineering graduates, you may go back to school, or you may convert to aircraft work by doing—on-the-job training. But whichever it is, you receive full pay while learning.

But Lockheed offers you more than a career. It offers you a new life, in an area where living conditions are beyond compare. Outdoor living prevails the year-'round. Mountains, beaches are an hour from Lockheed.

See your Placement Officer today for the details on Lockheed's Aircraft Training Program for engineers, as well as the better living conditions in Southern California.

If your Placement Officer is out of the illustrated brochures describing living and working conditions at Lockheed, write M. V. Mattson, Employment Manager

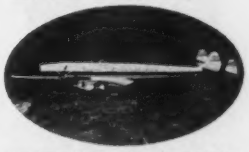
Lockheed Aircraft Corporation

Burbank, California

This Plane made History

The P-38 Lightning – first 400 mile per hour fighter-interceptor, the "fork-tailed Devil" that helped win World War II.

This Plane is making History

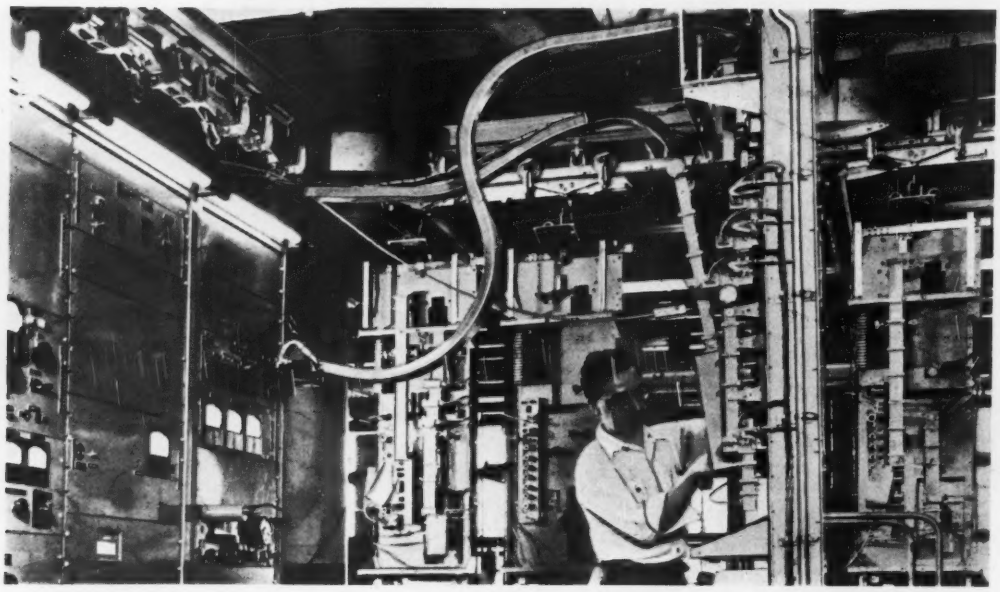


The Super Constellation – larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

This Plane will make History

This plane – which exists only in the brain of an engineer like yourself – is one reason there's a better future for you at Lockheed. For Lockheed will always need engineers with ideas, engineers with imagination, engineers who build the planes that make history.

Where engineering and pioneering go together!



The transmitter-receiver bay unit being worked on by a Western Electric tester, is part of the complex equipment installed in the Bell System's coast-to-coast microwave relay towers. Special testing equipment is at the left.

Operator inspects a grid blank. The grid controls the flow of power through the tiny electron tube which is the heart of radio relay. Western Electric engineers designed machines to wind wire .0003 inch in diameter on the grid at 1000 turns per inch—spaced exactly .0007 inch apart.

COMPLETION last Fall of the Bell Telephone System's coast-to-coast radio relay route climaxed a production feat that involved doing many things never done before.

The engineers at Western Electric—manufacturing unit of the Bell System—were treading on uncharted ground when they tackled the challenging job of making the highly complex equipment.

This radio relay equipment—which transmits telephone and television signals at a carrier frequency of four thousand megacycles per second—called for many components never made before and for which no machinery, no tools, no assembly processes were known. Some components required almost unbelievably tiny parts—and fantastically small tolerances.

Manufacturing facilities and techniques had to be developed to assemble and wire the complicated equipment which receives signals having less than 1/10 millionth of the power of an ordinary flashlight bulb—at frequencies ten times as high as those used in television sets—amplifies these signals 10 millionfold and transmits them to the next tower some 30 miles away.

Finally, Western's engineers were responsible for installing the equipment in 107 towers across the nation.

In all phases of this job, engineers of varied skills worked closely together as a team which just wouldn't be stopped merely because "it hadn't been done before." That's typical of work at Western Electric—where engineering and pioneering go together.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

full steam ahead!

(*Continued from page 10*)

built by the Stanleys held the world's record for speed for a long time after they went out of business. Although the record set was only about 128 miles per hour, the car which set it actually went over 190 miles per hour on the next try. But since it cracked up on that try, its speed record could not be counted officially. While going at top speed, the car hit a bad spot on the test beach. Its flat bottom caught the air and it took off, going more than one hundred feet in the air. It was aerodynamically unsound. The driver, Fred Marriott, was knocked unconscious, and the car was completely ruined. After this the Stanleys vowed never again to risk anyone's life racing their cars, so their record remained at 128 miles per hour. The drivers of these early days, as now, often did not realize how powerful the car really was. One fellow, trying to drive his car from the garage where it was being repaired, was puzzled when the car would not move even when the throttle was all the way open. The mechanic came over to see what the trouble was and pointed to the brake which was fully opened. The man released it and promptly went through the side of the building. By changing the position of the slide valves, it is possible to operate the Stanley in reverse exactly the same as in forward. Economy minded old New Englanders often saved on brake linings by shifting into reverse and letting the engine do the stopping. Since the reversing was not accomplished with gears, but by switching the steam to the other side of the piston, the engine could be reversed at any speed. This often led to interesting results because the reverse pedal is right where the brake pedal on an ordinary car is. One driver, confronted with an emergency, tramped his foot on the pedal only to find himself driving backwards sprawled halfway onto the hood. As soon as his foot left the pedal, the car started forward again, and the driver went ignominiously into the back seat. By this time the emergency, a small child, had long since run home screaming at the top of its lungs.

The kerosene burner in the Stanley often flooded, resulting in a fire. No harm came from such an occurrence, because the hood was a completely fireproof box. However, in the early days, the fire departments could not be so easily convinced. Often the driver who had flooded his burner found himself racing for his life to get away from an ambitious fire company. Sometimes he made it, but sometimes the obliging fire companies won out and doused the hard earned head of steam.

The major disadvantage of the Stanley was that it took about a half an hour to get up steam from a cold start. The boiler was equipped with a pilot light which maintained the steam pressure overnight or while parked, but the initial firing up process was no simple task. It was a ritual which started with heating up the burners with an acetylene torch and ended, much later, after much pumping and cajoling, in a head of steam.

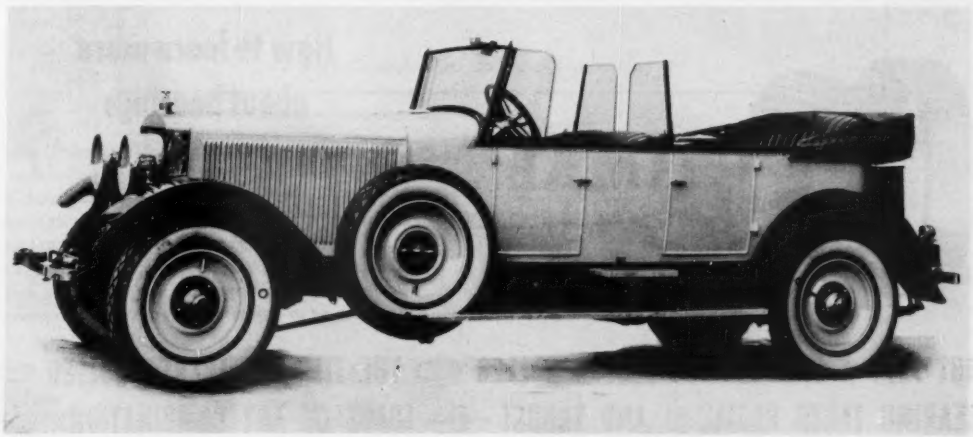
Other steam cars, notably the Doble, overcame this disadvantage by boiling the water only as it was needed. The Stanley had a large volume boiler, full of water; the Doble had a small volume boiler which was essentially empty. The boiler was in the shape of a coiled pipe. When this pipe was good and hot, water was squirted into it in a fine stream, and was vaporized immediately. This car could start from scratch in 90 seconds. The Doble burner was not at all like the Stanley burner. In appearance and action it was very much like a home oil burner. This was no coincidence. Doble's burner was the ancestor of the oil burner. The invention was not covered by patents well enough, and within a year after its development fifty companies were copying the principle. The Doble was a much better engineered car than the Stanley. Throughout the car, perfection was the goal. Superaccurate machining was done on all the moving parts and only the best quality materials were used. A Doble wearing out was just about unheard of. First of all, there is no carbonizing in the cylinders or corrosion such as is common in gasoline cars. Furthermore, all the moving parts were polished steel moving on polished steel.

It was Doble who first thought of condensing the steam and reusing the condensate in the boiler. Until then the limit of a steamer's journey was about thirty-five miles. With the condenser, a steam car can travel up to three hundred miles without adding water.

There has been a lot of speculation as to why the steam car industry failed. People say the oil interests

(*Continued on page 35*)

The five-passenger Doble phaeton touring car, which was one of the finest cars on the road in the twenties.



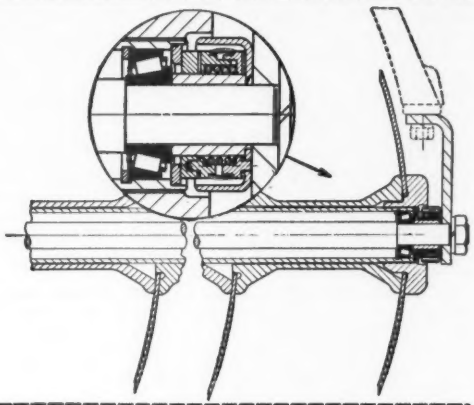
Another page for **YOUR BEARING NOTEBOOK**

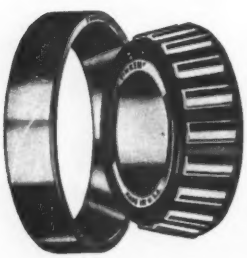
How agricultural engineers solve 3 design problems at once

Designing farm machinery applications like the through shafts of disk harrows presents three big problems to agricultural engineers: 1) combination loads, 2) dirt, 3) ease of operation. Engineers solve all three problems at once by designing the shafts on Timken® tapered roller bearings. Because they are tapered, Timken bearings carry both radial and thrust loads in any combination. They keep housings and shafts concentric, making closures more effective. Dirt stays out—lubricant in. And they keep shafts turning easily because of their true rolling motion and incredibly smooth surface finish.

How to mount disk harrow shafts on TIMKEN® bearings

Two single-row Type TS Timken bearings are indirectly mounted on a stationary shaft in a rotating disk assembly. The bearing cups are press-fitted against snap rings. The bearings are adjusted by means of shims between the bearing cone and shaft shoulder. A special spring-backed rubbing seal assures maximum protection to the bearings. The rubbing seal itself is protected by a shield fitted about the closure assembly.



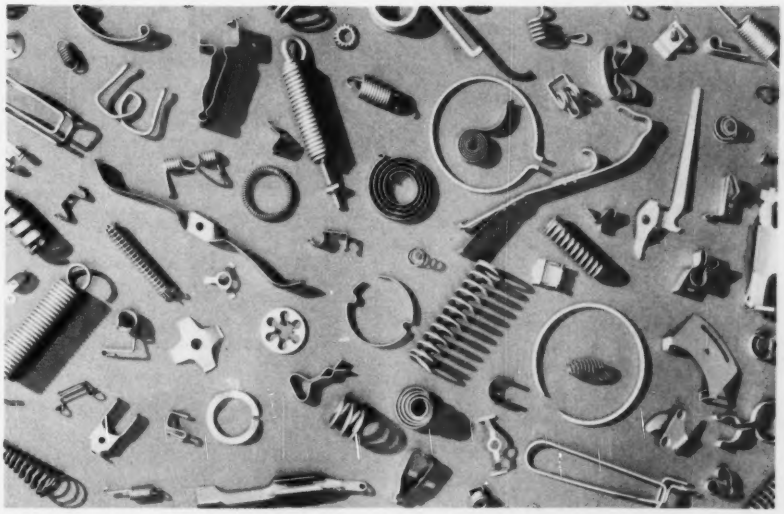


TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

How to learn more about bearings

Some of the engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about this phase of engineering, we'll be glad to help. For a copy of the 270-page General Information Manual on Timken bearings, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL ⬮ AND THRUST —◎— LOADS OR ANY COMBINATION ✳

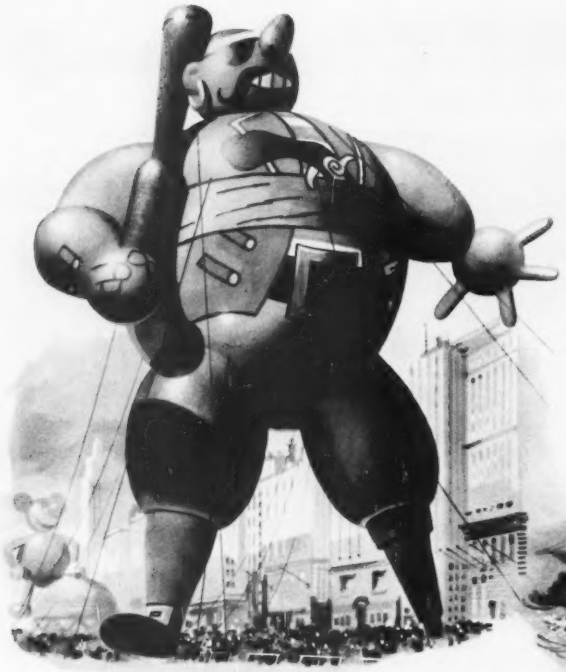


Whatever you do . . . Wherever you go . . .

Wallace Barnes Springs

will help you do it

WALLACE BARNES CO., BRISTOL, CONNECTICUT



how large?

The 40- to 75-foot trademarks of a world-famous Thanksgiving Day parade are inflated with helium. Lighter-than-air, this "safe" gas will not burn or explode.

how small?

From the eye-bright yellow "Mae West" to the life-saving raft of an Air Force pilot, CO_2, one of the family of Airco gases adds to the safety of American airmen everywhere.

at the frontiers of progress you'll find

AN AIR REDUCTION PRODUCT

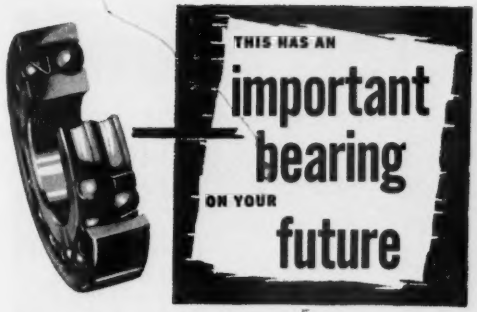
Big as a balloon . . . small as cartridge ampule, the range for needed gases is only one segment of the innumerable operations that link the Airco corporate family to many basic activities of American life — and industry . . . a corporate family that depends upon each individual member for its strength.

What is the strength behind Airco? — air and its constituent gases, plus the wide range of companion products that contribute to the comfort and convenience of daily life . . . from anesthesia to aircraft construction . . . from plastics to shipbuilding. In fact, wherever progress is racing ahead to new frontiers, you'll find an Air Reduction product.

AIRCO® **AIR REDUCTION COMPANY, INCORPORATED**

60 EAST 42nd STREET • NEW YORK 17, N. Y.

Divisions of Air Reduction Company, Incorporated, AIR REDUCTION SALES COMPANY, AIR REDUCTION PACIFIC COMPANY, AIR REDUCTION MAGNOLIA COMPANY... *Industrial Gases, Welding and Cutting Equipment* • AIRCO EQUIPMENT MANUFACTURING DIVISION • NATIONAL CARBIDE COMPANY... *Calcium Carbide* • OHIO CHEMICAL & SURGICAL EQUIPMENT CO., OHIO CHEMICAL PACIFIC COMPANY... *Medical Gases — Apparatus — Hospital Equipment* • PURE CARBONIC COMPANY... *Carbonic Gas and "Dry-Ice"* • AIRCO COMPANY INTERNATIONAL... *Export* • AIR REDUCTION CHEMICAL COMPANY



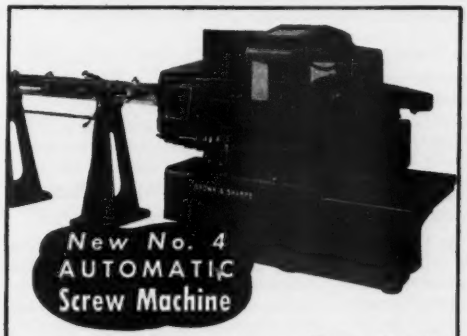
Elimination of wasteful friction is a constant battle confronting Industry. Out on the job . . . irrespective of your engineering role . . . you'll be coming to grips with this problem.

In *the past*, Industry has learned to rely upon SKF for practical solutions to anti-friction bearing problems.

In *the future* — more than ever before — engineers can look to SKF for the finest in bearings, plus help in putting the right bearing in the right place. 7234

SKF INDUSTRIES, INC., Philadelphia 32, Pa. — manufacturers of SKF and HESS-BRIGHT bearings.

SKF
BALL AND ROLLER BEARINGS



. . . for low-cost, medium sized Screw Machine Work

Modern in design, massive in construction, assures continuous, accurate production of medium size parts for cameras, automobiles, business machines, time fuses, etc. Wide range of speeds and high-to-low speed ratios, (168 two-speed combinations from 17 to 1965 R.P.M. in ratios from 2.2:1 to 13:1) make possible highest cutting efficiency on a wide variety of materials and work diameters.

Write for illustrated bulletin on the new No. 4 Automatic. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

BROWN & SHARPE BS

full steam ahead!

(*Continued from page 31*)

and the large automobile companies drove it out of existence. Actually this has some truth in it, but it is not the whole story. The final crushing blow to the Stanley company was the enactment of a law preventing one from entering a garage or service station. The law voided the insurance on the station if it allowed a car with an open flame to enter it, and the Stanley had an open flame, at least in the legal sense. The steam car companies themselves say that they failed because they could not get enough capital to continue properly. Although the competing interests were directly responsible for discouraging investment and probably sponsored the anti-steam car legislation, they would have failed to affect the industry materially if the general public knew more of the facts about steam cars. The steam car is perfectly safe in a service station, but people had been hearing rumors to the contrary. The reason these rumors persisted was the manufacturer's own attitudes about advertising. The Stanleys thought that their car was good enough to serve as its own advertising, and they were right, as far as sales were concerned. They never had any trouble selling their entire output. But rumors go farther and get there faster than reputation, no matter how good the reputation may be. When word had it that their boilers were always blowing up, the Stanleys tried to blow one up—and failed. They dug a hole in the back of their factory in Newton, Massachusetts, and placed a boiler in it hooked up to a steam generator. The normal operating pressure of the boiler is six hundred pounds per square inch. At 1,500 pounds pressure the boiler hadn't blown, but they couldn't get any more pressure from the generator. Needless to say, people still kept on hearing how the boilers were always blowing up. When word had it that the Stanleys were going out of business the Stanleys laughed, but when the investors of the company and, more important, the potential investors heard it they didn't know any better than to believe it. If more of the facts about the cars had been published, all of this might not have come to pass. But . . .

Although steam is much better suited for automobiles than gasoline in every respect except warming up time, it is far from ideal. Once you decide to condense the water and reuse it, you might as well look around and see if there is a better working fluid available. The main disadvantage with water is its high heat of vaporization. This means that a large part of the heat put out by the boiler is dissipated in the condenser instead of doing useful work. Other fluids than water are being investigated at this time, and many of them show promise. Mercury is not suited for a piston engine, but due to its high density, it makes a very good fluid for a turbine. It is expensive, to be sure, but there is a possibility that the amount needed can be reduced. Since it is the momentum of the stream of fluid hitting the plate which determines the power, only a relatively low velocity of the stream is needed. This means that it is not necessary for the turbine to travel at the ordinary high velocities encountered in a steam turbine. A steam turbine must turn at about thirty thousand revolutions per minute to be efficient. At these speeds, all sorts of bearing troubles arise. A mercury turbine only has to turn at about six thousand r.p.m. to attain comparable efficiency. Moreover only about half as much heat has to be dissipated in the condenser.

A car of revolutionary design, in order to be a success, will have to be more than just an improvement.

(*Continued on page 66*)

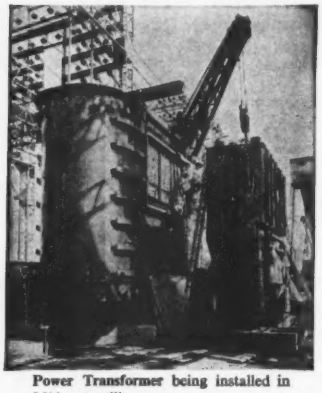
Make the First Job Count!

by PAUL CLARK
Application Engineer, Electric Control Section
WEST ALLIS WORKS
(Graduate Training Course 1950)
Iowa State—EE—1949

IT SUDDENLY occurred to me while I was a senior, looking for a job, that my first job would be all important. In a way, it was going to be almost as much a part of my schooling as my last year at "State."

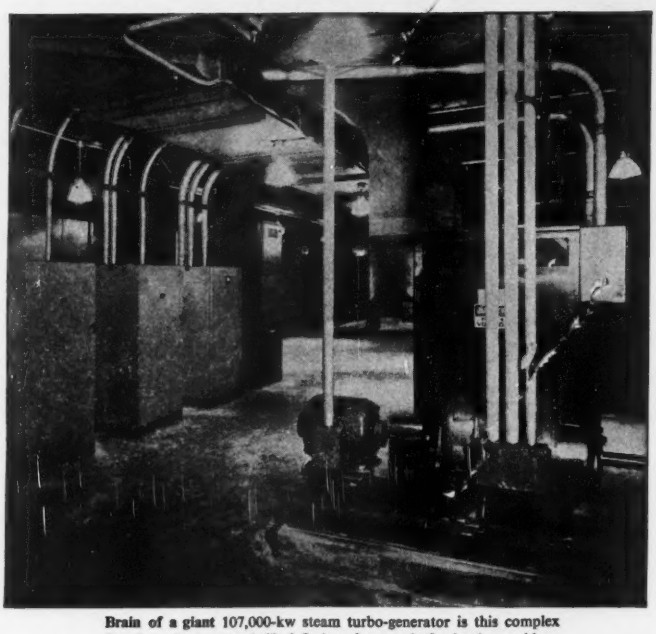
PAUL CLARK

Since then, I've been glad I thought of it that way, because that's what the first year and a half was . . . schooling. Among other things, I learned what I wanted to do, and learned a lot about products and industry problems. But I give much of the credit for the great amount I learned to the Allis-Chalmers Graduate Training Course and consider myself very lucky to have chosen Allis-Chalmers. Perhaps a quick review of my own experience will show why I feel that way.


Power Transformer being installed in Midwest utility.

After graduating from Iowa State in 1949

I started the Allis-Chalmers Graduate Training Course on the Steam Turbine erection floor. From there I went to the switchgear and pump departments to familiarize myself with other utility equipment; and from there, to the Motor and Generator section, which at the time was my goal.


Brain of a giant 107,000-kw steam turbo-generator is this complex *Regulex* voltage control. Clark finds such control a fascinating problem.

Arrange Your Own Course

From this, you begin to see the freedom a GTC student has at Allis-Chalmers. You not only have complete freedom in arranging your course, but you can change your course as you go along and your interests develop. Best of all, you have a wide choice, because Allis-Chalmers builds such a wide line of products.

Even after getting to the Motor and Generator section, which had been my original goal, I had a chance to change my mind. While I found a certain glamour to the big motors and generators, I became *really* intrigued by the electrical brains of these giants, and decided to go to the control section to learn more about them. I have been working there ever since.

Today, I am in charge of pricing, applying and promoting the sale of three lines of control devices: *Rocking Contact* voltage regulators; *Regulex* voltage regulators; and liquid rheostats. Part of my time is spent traveling . . . visiting customers and helping district office salesmen.

The time spent in other departments has paid off too. It not only helped me find the work I liked best, but I met people in departments all over the plant that I now work with in coordinating jobs for utilities. Even time on the Steam Turbine erection floor proved valuable, because it helps me in talking shop to utility men.

Wide Choice at A-C

One reason you have such a wide choice is the fact that Allis-Chalmers makes equipment for every basic industry, including electric power, cement, mining, rock products, flour milling, and steel. Just to give you an idea, here are some of the products you might some day redesign, build or sell: transformers, steam condensers, pumps, motors, blowers, unit substations, steam and hydraulic turbines and generators, crushers, kilns, grinders, coolers, rolling mills, sifters, and many others.

That diversity can mean a lot to you in helping you find the job you want. It certainly helped me make my first job count.

Rocking Contact and *Regulex* are Allis-Chalmers trademarks

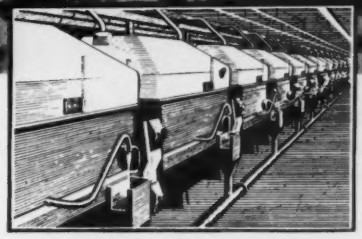
ALLIS-CHALMERS

For information call the Allis-Chalmers District Office in your locality or write to Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

Although Corpus Christi lies almost at the tip of Texas, on the shore of the salty Gulf of Mexico, Columbia-Southern has brought billions of gallons of brine to its plant there, from the great Palangana salt dome, 60 miles inland. This is less of a paradox than it seems, for with the huge quantities of brine involved in the manufacture of chlorine, caustic soda and other alkalies, it is far more costly to purify and produce saturated saline solutions from sea water on such a scale.

The brine is transported through a 14″ pipe line—the nation's longest cast iron line at the time of its construction in 1933. A down-hill flow the entire distance, the capacity is over a million gallons per day—equivalent to more than 125 tank cars of brine, or 30 freight cars handling 2,500,000 pounds of solid salt!

This is one of numerous unique features of Columbia-Southern's Corpus Christi plant—the pioneer alkali operation in the Southwest, and a forerunner of the tremendous chemical expansion in that area. Other Columbia-Southern plants serving industry's needs for alkalies and related chemicals are located at Lake Charles, Louisiana; Barberton, Ohio; Natrium, West Virginia; Bartlett, California.



THE ELECTROLYSIS OF BRINE

Basis of most chlorine production—and therefore a large share of the production of its principal co-product, caustic soda—is the electrolysis of aqueous solutions of sodium chloride.

Using diaphragm cells of ingenious design, the electrical decomposition results in chlorine gas, hydrogen gas and liquid caustic soda.

Chlorine and caustic soda are essential in the processing and production of a multiplicity of products and rank among the most important of all the world's manufactures. Columbia-Southern is one of the major producers of chlorine, caustic soda and other alkalies and related chemicals.

COLUMBIA-SOUTHERN CHEMICAL CORPORATION

SUBSIDIARY OF PITTSBURGH PLATE GLASS COMPANY

EXECUTIVE OFFICES: FIFTH AVENUE AT BELLEFIELD, PITTSBURGH 13, PENNSYLVANIA ***DISTRICT OFFICES:*** BOSTON • CHARLOTTE CHICAGO • CINCINNATI • CLEVELAND • DALLAS HOUSTON • MINNEAPOLIS • NEW ORLEANS • NEW YORK PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO

SODA ASH • CAUSTIC SODA • LIQUID CHLORINE • SODIUM BICARBONATE • CALCIUM CHLORIDE • MODIFIED SODAS • • CAUSTIC POTASH • CHLORINATED BENZENES RUBBER PIGMENTS (Hi-Sil, Silene EF, Calcene TM) • MURIATIC ACID • PERCHLORETHYLENE • PITTCHLOR

Easy way to get rich

SUPPOSE, as you enter a grocery store, you suddenly find the denomination of every bill in your pocket has doubled! You're rich! Until you find that the same "magic" has doubled the price of everything in the store.

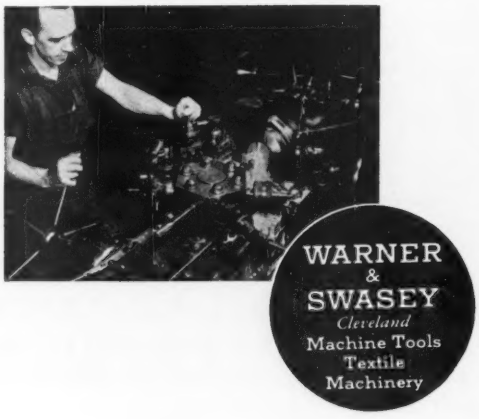
That's the sort of "prosperity" America has been "enjoying."

Most Americans feel they're worth more today than a few years ago; actually their savings have been whittled away 23% in the 7 years since the war. *More money without more goods* always bids prices up and up to the sky.

If you like what's been happening to you, if you think this is prosperity, let's make a *good* job of it; let's make every bill a *million* dollar bill—or a *billion*, as Germany did. If inflated money makes everybody happy, let's be hysterical!

But Germany didn't find it much fun, the morning after.

Source: "How to Keep Our Liberty" by Raymond Moley. Published by Knopf, 1952



YOU CAN MACHINE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY TURRET LATHES, AUTOMATICS AND TAPPING MACHINES

(*Continued from page 11*)

Using twenty-six letters and a space, Shannon illustrates the results as follows:

1. Zero order approximation to English (symbols independent and equi-probable).

XFOML RXKHRJFFJUJ ZLPWCFWKCYJ FFJEYVKCQSGHYD QPAAMKBZAACIBZLHJQD

2. First order approximation (symbols independent but with frequencies of English text).

OCRO HLI RGWR NMIELWIS EU LL NBNESEBYA TH EEI ALHENHTTPA OOBTTVA NAH BRL.

3. Second order (digram structure as in English).

ON IE ANTSOUTINYS ARE T INCTOR ST BE S DEAMY ACHIN D ILONASIVE TUCOOWE AT TEA SONARE FUSO TIZIN ANDY TOBE SEACE CTISBE.

4. Third order (trigram structure as in English).

IN NO IST LAT WHEY CRATICT FROURE BIRS GROCID PONDENOME OF DEMONSTURES OF THE REPTAGIN IS REGOACTION OF CRE.

Now let us return to the problem of measuring the information of such a system. We notice that the ultimate arrangement of the symbols depends on the probability of each occurring (frequency) and the additional probability of each occurring after any other. Intuitively we feel that there is one arrangement of all the symbols which is most probable. That is, if there are i arrangements of the symbols, one of these arrangements will most ably satisfy the probabilities associated with frequency and position. This arrangement we call the most probable. With this outlook on the problem it is no surprise that we come into contact with the concept of entropy. This concept is statistical in nature and deals with the probability of states, a concept which fits perfectly into the above situation.

Entropy is a measure of the randomness of a system. The second law of thermodynamics states that the entropy or randomness of a system must increase; thus the ultimate, and therefore most probable state of a system is the most random one. For instance, let a stream of gas atoms, each having the same velocity, pass through a small hole in an empty box. At first their motion is highly organized. We assume that if we wait long enough the atoms will arrange themselves so as to effect equilibrium. This arrangement, in which the organization of velocities does not change, is the most probable arrangement. Noting that the entropy H is the measure of randomness, we find that H is largest for the case when all the symbols have the same probability of occurrence. Indeed, it can be shown that our original definition of information is just this special case of equal probabilities. We originally defined the amount of the information as equal to the logarithm of the number of choices, where all choices were equally likely. We would expect, then, that the information should be less as the probability of certain symbols increased to one or decreased to zero. At the values one (certainty of occurrence) or zero (certainty of absence) we would expect the information to become zero, for we would then have *no choice* as to their occurrence. Entropy satisfies these conditions. Entropy thus can be used as a measure of information. An interesting observation is that the information of a message is not increased when we add to it a symbol whose probability of occurrence is one (can be predicted with certainty). For instance, we can predict with certainty the remaining symbols of, "Now is the time for al . . . ." Thus, no information is added to the message by including these symbols.

The fact that in ordinary language we use more symbols to encode messages than are theoretically necessary leads to the concept of redundancy. The redundancy R of a system is defined as

$$R = 1 - \frac{H_{(\text{actual})}}{H_{(\text{max.})}} = 1 - \text{relative entropy.}$$

Redundancy is a property of language which is often necessary for meaning. If we miss part of a message, as ". . . Fo, Fum, I smell . . . blood . . . man," the missing portion can be supplied by contextual clues. It is also necessary where spurious signals, e.g., noise, are present in the channels. A Morse code operator may copy the following, "eleven year old infant kidnapped." We are aware that a mistake has been made, for, indeed, eleven year old infants are rare items.

Another problem of extreme importance is the capacity of any channel to transfer information from the transmitter to the receiver. If we have a source which contains 2^s symbols, so that it can be said that each symbol chosen represents s bits of information, and if a channel can send n symbols per second, then C, the channel capacity, is ns bits per second. Shannon states that, for a noiseless channel, C/H is the maximum rate symbols can be transmitted. It turns out that channels with noise also have a limited capacity; no more than ns bits of information can be transmitted per second, no matter how clever the encoding.

Now that we have considered the theory of information from the technical viewpoint, we can consider some of its implications. First, as George Weaver states, it has cleared the way for a theory of meaning. In his words, "One can imagine another box labeled 'Semantic Receiver' interposed between the engineering receiver (which changes signals to messages) and the destination. This semantic receiver subjects the message to a second decoding, the demand on this being that it must match the statistical *semantic* characteristics of the message to the statistical semantic capacities of the totality of receivers. . . .

". . . it seems highly suggestive for the problem (of meaning) . . . that error and confusion arise and fidelity decreases, when, no matter how good the coding, one tries to crowd too much over a channel (i.e., when $H > C$). Here again a general theory . . . will surely have to take into account not only the capacity of the channel but also . . . the capacity of the audience. . . . if you overcrowd the capacity of the audience you force a general and inescapable error and confusion."[1]

He indicates also that the concept of entropy may play an important part in a development of such a theory. From the analysis presented above we can see why this is so. The meaning of any part of a thought is dependent on the meanings assigned to past thoughts. Thus, there must exist an arrangement of meanings which has a definite probability of occurrence.

The question that still concerns us, however, is how this theory indicates the way out of the dilemma posed in the introduction. The first step is in the production of a universal language easy enough to learn and communicate, yet redundant enough to prevent errors. This has already been done.

The second step is the determination of just how

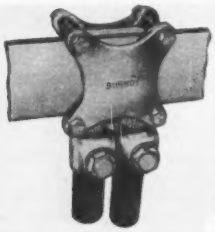
[1] Weaver, George, "Recent Contributions to the Mathematical Theory of Communication," University of Illinois Press, page 115.

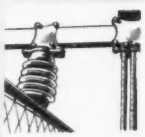
(*Continued on page 43*)

PROBLEM: To join or terminate any electrical conductor—anywhere

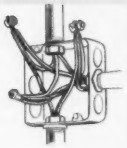
SOLUTION: BURNDY CONNECTORS

Wherever electrical conductors are joined, terminated, clamped or grounded —you'll find Burndy connectors completing the circuit . . . safeguarding the circuit. Right down the line, from mammoth industrial or utility installations to house service drops . . . from B-36's to washing machines Burndy connectors are included in the most exacting engineering specifications. Wherever your job takes you, you'll find Burndy connectors on the job, too. Here are just a few examples of Burndy-engineered connectors:

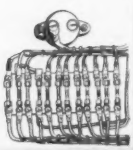




BURNDY BARTAP
Burndy has developed a complete line of heavy-duty connectors—standard and special shapes—of high current capacity. Used in utility substations, industrial power houses, hydro-electric projects, etc.



BURNDY SERVIT
Most versatile, efficient and popular split-bolt connector for splices, taps, dead-ends. Used and re-used for sizes #12 Str. to 1000 Mcm. Variations available for aluminum and steel conductors, and for combinations of these and copper.



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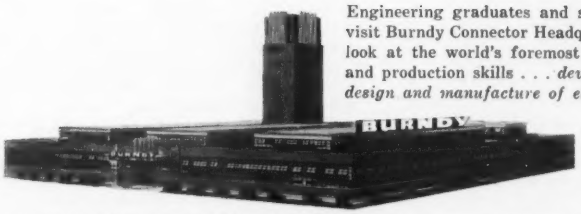
These compression splices, installed by Burndy hydraulic tools, are used in power transmission lines, where joints require maximum conductivity, highest mechanical strength.

BURNDY HYLUG
Solderless connector of one-piece, pure copper construction—with longitudinal indent method of installation. Adaptable to economical mass-production, used in thousands of plants manufacturing electrical equipment. *A Burndy exclusive.*



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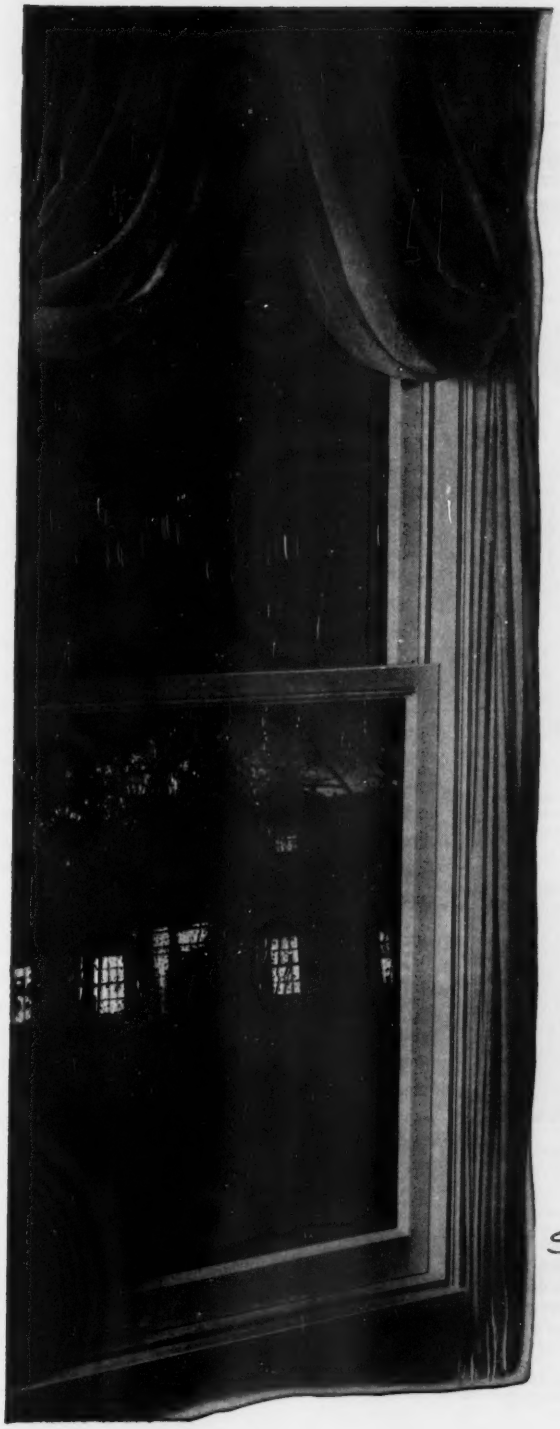
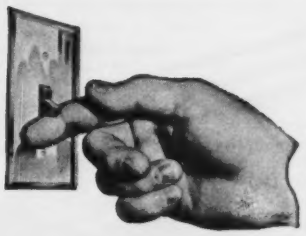
52-25 **BURNDY ENGINEERING COMPANY INC.,** NORWALK, CONNECT. **BURNDY CANADA LTD.,** TORONTO 8, ONT.



Gloom chaser . . . that works

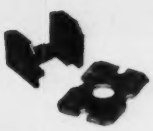


Fair weather or foul, when you flip a light switch you *expect* light. You take it for granted. Actually, like a touchdown in football, the result is the triumph of teamwork in electrical apparatus.

The power company is the captain. The players include the manufacturers of generators, transformers, switch gear, and electrical fixtures. But an *unseen essential* called *Synthane* is present, too.

Synthane is a laminated plastic. It is an excellent electrical insulator. It is also a mechanical material that combines light weight and strength, a chemical-resistant material that machines easily.

Send for the complete Synthane Catalog. Then, if you find Synthane a material you can use, we will be glad to help you with design, sheets, rods, tubes or fabricated parts. Synthane Corporation, 10 River Road, Oaks, Pennsylvania.



Insulator (left) made from Grade X Black Synthane for Square D Company and switch mounting plate made for Cutler-Hammer Inc. of Grade GLCC-M Synthane. Both parts require good electrical characteristics.

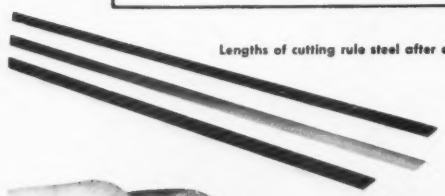
Synthane-one of industry's unseen essentials

SYNTHANE

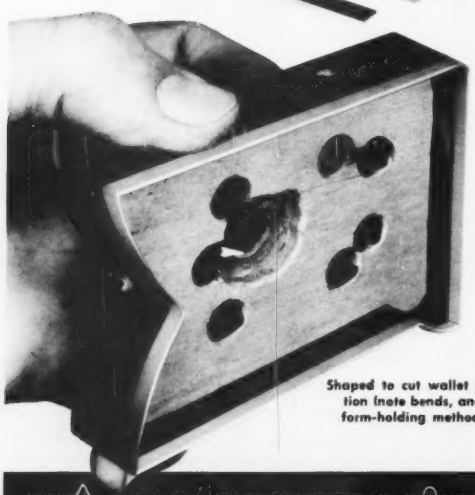
LAMINATED PLASTICS

What's Happening at CRUCIBLE

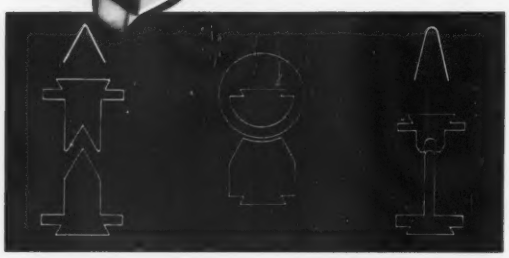
about scoring and cutting rule steel



Lengths of cutting rule steel after edging



Shaped to cut wallet section (note bends, and form-holding method)



Some examples of the many shapes of bends needed

Scoring and cutting rule steel is a cold-rolled specialty steel for use in preparing dies for cutting paper, leather, rubber and other materials.

It is a pre-tempered product manufactured by skilled workmen, using precision rolling and hardening equipment, to close limits for chemistry, grain size and hardness. This product must also be capable of meeting intricate bend requirements in the hardened and tempered condition.

This specialty is furnished with round edges and in coil form to the rule manufacturer who grinds the edges — the one edge square and the other to a knife edge as well as cutting the material into desired lengths. This is sold to a die-maker who bends the rule to the required shape. This is then the nucleus of a pre-hardened die, which when properly brazed and supported is used to cut out material for display cards — aircraft parts — pocketbooks — wallets — gloves — gaskets — washers.

engineering service available

Since there is a great diversity of cold-rolled products, our staff of field metallurgists can help you apply what you require. Take full advantage of Crucible's more than 50 years experience as the first name in special purpose steels. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

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WHERE
TENSION CONTROL
AND LEATHER
make a good team
FLAT LEATHER BELT
TENSION-CONTROLLING MOTOR BASE
In the fielder's glove, a hand controls the tension that makes the leather take hold. In the Uni-Pull drive, a tension-controlling motor base and a modern leather belt team up in practically the same way. The base maintains belt tension . . . keeping leather's high pulley grip at work, effectively transmitting power.
American LEATHER BELTING Association
Headquarters for Authentic Power Transmission Data
61 PARK ROW, NEW YORK 38, NEW YORK

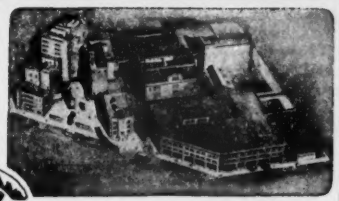
challenges of communication

(*Continued from page 43*)

great is man's gregariousness. This has been done to some extent. One method used was putting several men in different rooms with a telephone communication net between them. However, they were arranged so that one man could communicate with only one person, another with three, another with all of them. They were then assigned a task of solving a problem by working together. It was found that those who were in contact with the most people enjoyed the task more, while those in contact with only one or two enjoyed the task least. The determination of this characteristic, however, has not gone far enough.

Once enough data has been acquired, once Shannon's theory has been extended into meaning and the dependence of society on the communication of meaning, then the scientists and the scientifically minded laymen will find a meeting ground in belief that a social structure which tends to restrict communication makes its own existence impossible. It is such a group, with its overwhelming intelligence, that must be looked to to foster free communication through one international language and one interculture society.

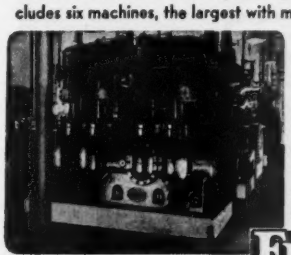
Philadelphia's Largest Brewery Uses 2300 Horsepower of



FRICK Refrigeration

C. Schmidt and Sons, Inc., founded in 1860, now make over a million barrels of beer and ale annually in their plant on Edward Street.

A pair of Frick four-cylinder ammonia compressors was installed at Schmidts' twelve years ago. Today this battery includes six machines, the largest with motors of 450 hp. each.



Six Big Frick Compressors at C. Schmidt and Sons' Brewery

For dependability, stick to Frick Refrigeration.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, offers a career in a growing industry.

FRICK CO.
WAYNESBORO, PENNA.
Also Builders of Power Farming and Sawmill Machinery

technologist as man and citizen

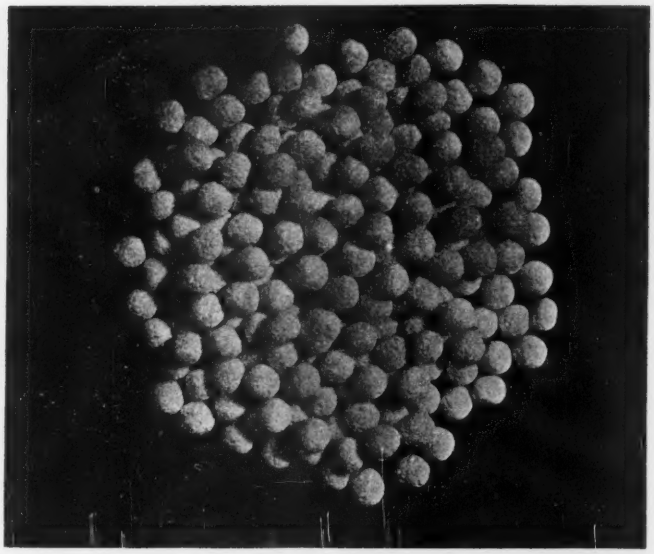
(*Continued from page 27*)

government at M. I. T. valid? In essence, we have already answered this question. Any community of free men must have laws and a government to make and enforce those laws. If men are to remain free, government must be the servant of all the people and representative of all the people. When we fail in our responsibilities as part of the body politic and leave government to the politicians, then we soon desert our ideals and stand the grave threat of losing our freedom either to the politicians who serve their own selfish ends, or to some benevolent dictator — which in M. I. T.'s case would be the Faculty and Administration — who takes over to protect the interests of the people, but once he has power in his hands, is reluctant to let it go. The answer is that student government at M. I. T. is entirely valid. Its continued strength depends on the electorate (the student body) having a devotion to the ideals and traditions of the Institute, a clear-cut understanding of its areas of responsibility for its own government.

In summary, life is a continual process from life in the family, to school and college, to an occupation and the founding of another family, to the responsibilities of citizenship. Education, at any level, is just part of the process of living and preparing for the life that still lies ahead. The Declaration of Independence states as our goal, "life, liberty, and the pursuit of happiness." The technologist who is not developed as a man and not prepared for citizenship cannot hope to reach this goal.

What Are These Spheres?

- ☐ *Catalyst Supports*
- ☐ *Moth Balls*
- ☐ *Abrasive Grains*



They are catalyst supports — Norton refractory products made of chemically inert, heat-resistant, wear-resistant materials for use as catalytic carriers in chemical processes. Pictured in spherical shape here, they are also available as pellets and rings.

Composition and Properties

These supports are commercially available in ALUNDUM* (fused alpha alumina) mixtures varying from 77% to 89% alumina with silica as the principal impurity. In addition to their refractoriness, they are chemically inert, mechanically strong and wear-resistant.

Water absorption values of these supports vary from 12% to 22% by weight. Surface areas by the nitrogen absorption method range up to about one square meter per gram. Crushing strengths vary from 20 to 600 pounds, depending on size and shape, and bulk densities range from 60 to 80 pounds per cubic foot.

Many Refractory Products

Catalyst supports are but one of many refractory products made by Norton. These include small furnace refractories such as tubes, cores and muffles; large furnace refractories such as bricks, plates, muffles and other shapes; refractory cements; refractory laboratory ware; kiln furniture for ceramic plants.

In its search for refractory products that can be used at higher and higher temperatures, Norton has developed a line of pure oxide refractories. These refractory shapes, as their name implies, are molded without bond and then fired at sufficiently high temperatures to produce a truly sintered product.

The principal raw materials used in the manufacture of Norton pure oxide refractories are ALUNDUM (fused alumina), MAGNORITE* (fused magnesia), fused stabilized ZIRCONIA and, to a limited degree, fused thoria.

Planning Your Future?

Norton Research is continually developing better products to make other products better. Young technicians who are interested in contributing to the technical advances of the future will find Norton Research well worth investigating.

Free Booklet on

longer lasting Norton refractory products contains detailed descriptions of Norton contributions in this field. Write for your copy.

Norma L. Gullberg, A.B., Chemistry, Clark University '46, takes a reading with an optical pyrometer on a high temperature furnace used for catalyst support tests.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

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Takes a lot to lay a carpet in the jungle

The scene is "darkest Africa".

But Africa is lightening. Man's quest for minerals, for new areas for agriculture and trade, is slashing ultra-modern, glaring-white air strips in once impenetrable jungle.

Those pavers, portable air compressors, pumps and air tools—such as you might see working a city street—are Worthington Blue Brutes going to "lay a carpet" in that hole in the jungle.

Thus, Worthington, a major producer of equipment for public works, industry and farm, brings the fruits of American technical genius to the strange places of the world.

And illustrates, too, how the unique American talent of *diversification* helps public, employees and stockholders. For Worthington makes many things—not just construction equipment and pumps, but also engines, water works machinery, power transmission, petroleum equipment, air conditioning and refrigeration, many others.

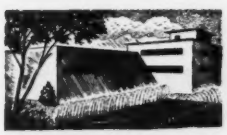
Such diversification builds *stability* . . . makes Worthington, 112 years old, a strong link in the chain of American business.

Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Harrison, New Jersey.

WORTHINGTON

The Sign of Value Around the World

1.14



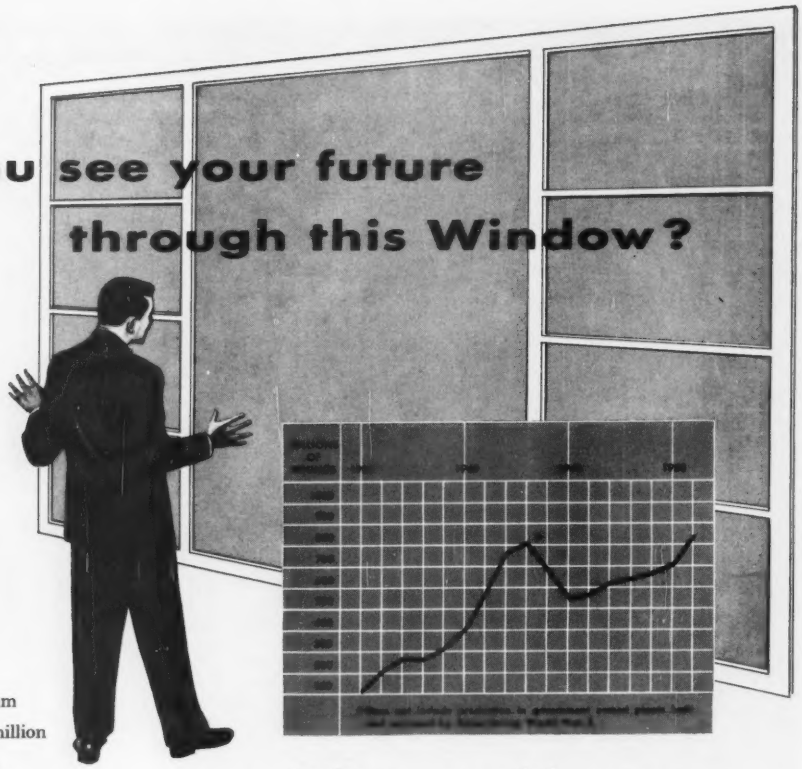
Good Water and Sanitation—engines · pumps · water treatment · comminutors · air compressors · air tools

Lower-Cost Manufacturing—pumps · compressors · steam turbines · motors · power transmission · air conditioning

Petroleum Products—compressors · engines · pumps · chilling equipment · refrigeration · decoking systems

More Abundant Food—compressors · fertilizer mixers · air conditioning · refrigeration · pumps

Can you see your future through this Window?



This is an aluminum window, one of four million that will go into buildings in 1953. Twenty years ago, it was just an idea in the mind of an Alcoa development engineer. Ten years ago, only a few thousand were made annually. Now, production *is increasing* at the rate of over half a million a year. This is just one of a torrent of new uses for aluminum which means that Alcoa must continue to expand. Consider the opportunities for you if you choose to grow with us.

What can this mean as a career for you?

This is a production chart . . . shows the millions of pounds of aluminum produced by Alcoa each year between 1935 and 1951. Good men did good work to create this record. You can work with these same men, learn from them and qualify yourself for continually developing opportunities. And that production curve—is still rising, we're still expanding, and opportunities for young men joining us now are almost limitless.

Ever-expanding Alcoa needs engineers, metallurgists, and technically minded "laymen" for production, research and sales positions. If you graduate soon, if you want to be with a dynamic company that's "going places", get in touch with us. Benefits are many, stability is a matter of proud record, *opportunities are unlimited.*

For more facts, consult your Placement Director.

The best things in aluminum come first in ALCOA ALUMINUM

By ALUMINUM COMPANY OF AMERICA · Pittsburgh, Pennsylvania

riddle of the stars

(*Continued from page 14*)

cannot observe any increase in temperature of the sun in the comparatively short time that we have been making observations. A billion years would hardly make a noticeable difference in the surface temperature of any young star. But once a temperature increase does occur, the radiation will increase rapidly. Supposedly a star spends nine-tenths of its life burning up the first half of its fuel. This will have great importance to the inhabitants of the earth billions of years in the future; they will have the pleasure of frying instead of freezing.

Obviously the star cannot continue to become hotter indefinitely; eventually the hydrogen supply will be exhausted. When this occurs, the star probably resorts to its original mode of energy production, gravitational contraction. However, the gravitational energy is very small compared to the vast amounts released by the hydrogen-helium conversion. The star contracts rather rapidly; for a few million years it remains very hot but becomes very dense. Such stars have been observed. A typical example of these "White Dwarfs," o-Eridani, have a surface temperature of 11,000 Centigrade, twice that of the sun; but a density of 60,000 times that of the sun or 84,000 times that of water. One cubic inch of this star would weigh about a ton on earth. Yet this star is still hot, and will continue to contract until it has converted all of its gravitational energy into radiation. When it is finally cold, it will have a density of a million tons per cubic inch!

Eddington noticed that a very strange situation should be predicted from theory. As the star uses up its hydrogen and cools, the atoms should regain the electrons which were formerly too energetic for them to retain. The effective size of the atom should hence increase, and the star should expand. But the expansion would involve work against gravity. Hence the star would have to have additional energy in order to cool!

The best explanation of this dilemma comes from the Indian astronomer Chandrasekhar, who calculated that an atom can be squashed flat by sufficient pressure. The atom behaves like a rigid sphere ordinarily because of the repulsive forces of the outer electrons. But under sufficiently high pressure not even an electron is repulsive enough, and the atom collapses. The new state of matter, with closely packed nuclei and electrons, is similar to a gas and is dubbed a "Fermi gas" after Enrico Fermi, who investigated it mathematically.

Fermi's theory leads to the result that the pressure of a Fermi gas increases as the five-thirds power of the mass. But gravitational forces increase as the square of the mass. Hence the addition of mass to a Fermi gas increases the gravitational forces more than the gas pressure, and the gas must contract until the forces balance.

These calculations lead to a rather surprising result. If we start out with a small amount of cold matter and add more and more material, at first the volume increases in proportion to the mass. This is as we would expect. But when the internal pressure of the mass is enough to collapse the atoms and form a Fermi gas, the more mass we add, the *smaller* the volume gets. The gravitational forces increase faster than the resistive pressure, and the mass has to contract in order to restore equilibrium. The calculations show that the planet Jupiter is about as large as any cold object can get! If the sun were cold, for example, it would be the size of the earth. Its density, of course, would be enormous (about 2×10^6 grams per cubic centimeter). Thus cold stars present a strange paradox: if one adds material to them, they get smaller!

Naturally, there is a limit to the density of matter. This corresponds to the point where the nuclei of the original atoms are jammed up close to one another. The density of this mass would be about 10^{12} grams per cubic centimeter; a scarcely visible speck would weigh tons. This state is reached at only 1.4 sun masses, and the radius of such a collapsed star would be only one hundred miles. The diameter of the earth would be less than one mile at such densities!

The theory of gravitational collapse, hydrogen into helium conversion over a long time interval, and then a final gravitational collapse into a superdense dwarf fits most of the observed facts. But it has its difficulties too.

Most of the stars we observe follow the Mass-Luminosity Relation which Eddington derived before the carbon-nitrogen cycle was known. The C-N cycle changes the derivation in that the central temperature should increase with time; hence, the luminosity at a given mass should increase with time. But we have already mentioned that there is good experimental verification of the Mass-Luminosity Relation. Therefore, *most of the stars we see seem to be about the same age.*

But if all of the stars somehow started their contraction at the same time, we would expect *all* of them to obey the Mass-Luminosity Relation. But, unfortunately, exceptions to the Relation are fairly common. On one hand, there are the "Red Giants," huge, cool stars which fit perfectly into the theory that they are still contracting under gravity and haven't reached the temperature required for the C-N cycle. But if this is the case, they somehow started their contraction only a few million years ago, or millions of centuries after the "ordinary" stars like our sun began the cycle.

Just as puzzling are the aforementioned "white dwarfs," hot, superdense stars which are apparently the end products of stellar evolution. Again the same dilemma. Are these stars really older than the vast majority of their kindred? Or were they born with gray whiskers? It is doubtlessly frustrating to a theoretician to have the perfect confirmation of his theory right before his eyes, only ten billion years too early.

There are a few remaining types of stars which do not fit into the theory at all. The most famous of these are the "cepheid variables," or stars which for some reason change their volume and luminosity periodically. Dr. Harlow Shapley of Harvard noticed a very important fact about these cepheid variables; their period of pulsation increases with their mass, and hence with their absolute luminosity. Since their absolute luminosity can be measured from the period, and the apparent luminosity observed by the earth is proportional to the absolute luminosity divided by the square of the distance. The distance can be calculated from the star's brightness and the period of pulsation. These stars serve as the principal means of measuring great astronomical distances.

Much more dramatic than a regular pulsation in the luminosity of a star, however, is a sudden and violent explosion, called a nova, which can increase the luminosity of a star by thousands of times in a day or so. The star seems to blow apart suddenly, for no apparent reason. A normally invisible star will become one of the brightest in the sky overnight. The increase in light is sudden, but the luminosity falls rather slowly, perhaps over a period of months, to a value usually below the original one. The star seems to discharge gas

(*Continued on page 51*)

"MAN-MADE MINERALS"

contribute immeasurably to life's pleasures...

THIS PORTABLE OUTDOOR ROTISSERIE is equipped with GLOBAR electric heating elements made not of metal but of "man-made minerals." These elements reach maximum heat in seconds, thus help seal in meat juices for moist, succulent, tender steaks and roasts.

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A process of the Coated Products Division

AUTOMOBILE MASS PRODUCTION owes much to "man-made minerals." A remarkable form is FERROCARBO, a deoxidizer used in many metallurgical processes. Added to the molten metal, this product by CARBORUNDUM produces metal that yields stronger, cleaner, easier-to-machine castings, of which the motor car industry utilizes millions.

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"The pleasant life" is vastly more pleasant today than ever before—in large measure because of the "man-made minerals," silicon carbide and aluminum oxide by CARBORUNDUM. These products of the electric furnace have been put to work in an infinite variety of ways to lower the cost of luxuries and necessities alike, and so to make them available to more and more people.

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Uniformity gained by "Centrifugal Casting"

The great majority of cast iron pressure pipe produced today is cast centrifugally, in metal or sand-lined molds.

When this mechanized process was introduced 27 years ago, its potentialities for improved production controls were evident. For human fallibility was largely replaced by machine accuracy based on scientific principles.

The improved production controls made possible by the centrifugal casting process have long since been realized. Hundreds of millions of feet of centrifugally-cast-iron pressure pipe are now in service. All of this pipe is more uniform in metal structure, in wall thickness, and in concentricity, than pipe not centrifugally cast.

Better production control means better pipe; it results in greater uniformity of quality.

Production controls in cast iron pipe foundries start almost literally from the ground up with inspection, analysis and testing of raw materials; continue with constant control of cupola operation by metal analysis; and end with rigid tests of the finished product.

By metallurgical controls and tests of materials, our members are able to produce cast iron pipe with exact knowledge of the physical characteristics of the iron before it is poured into the mold of a centrifugal casting machine.

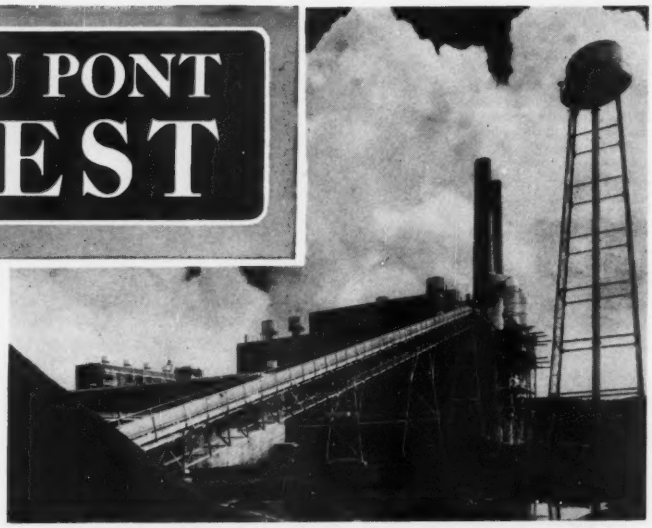
Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction.

Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Avenue, Chicago, 3, Illinois.

Section of 114-year-old cast iron gas main still in service in Baltimore, Md.

CAST IRON PIPE SERVES FOR CENTURIES

THE DU PONT DIGEST



This powerhouse *for a nylon plant at Martinsville, Va., was designed by Du Pont engineers. It houses two 135,000 lb./hr. boilers and two 7,500 KW extraction turbine generators.*

Power Work for M.E.'s

Varied needs of 71 Du Pont plants pose a host of original power problems

Heart of Du Pont's manufacturing program is the power plant. To make some 1200 products and product lines the Company operates 71 plants.

Most require steam and electric generation, water supply and treatment, heat exchangers, piping systems and related services. The designing of these power plants, their erection and operation are all in the hands of engineers, the great majority being mechanical engineers.

But this is not the most interesting thing about power work here. What challenges the highest skills of the engineer at Du Pont is the wealth of original problems constantly arising. Power requirements vary enormously, not only from plant to plant but from time to time.

Process operating pressures may range from over 15,000 psi. to 2 mm of mercury, electrical requirements from as low as 7,000 to higher than 1 million KWH/day, and temperatures from −360° to over 3,500°F.

George S. Mahaffey, *B.S. in M.E., Penn State '52 (right), B. S. Norling, B.S. in E.E., Washington State '24, and A. S. Noell, Jr., B.S. in E.E., Duke '51, discuss the power requirements of a new processing area.*

Here are examples of recent "off-the-beaten-path" power problems.

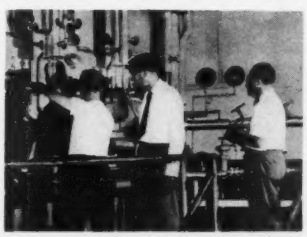
1. A plant using natural gas as its basic fuel produces a waste oil of variable hydrocarbon composition and a waste gas with only 110 Btu/cu. ft. Du Pont M.E.'s designed burners, fans, boilers and combustion controls to permit use of all three fuels for generating steam.

2. At another plant 20,000 gpm of cooling water were to be drawn from a nearby river. Since the water level fluctuated 40 feet between normal and flood stages, it was necessary to evaluate several plans for pump-house constructions against cooling towers. The engineers installed a unique pump house whose submerged vertical pumps operate even when the structure is entirely under water.

Aside from design and construction, Du Pont mechanical engineers concern themselves with such related subjects as economic evaluations, equipment selection, heat balances, load calculations, waste heat boilers.

For example, where various process temperatures from 300° to 600°F. were required, Dowtherm was selected as the supply medium at the rate of 35 million Btu/hr. The engineers installed a central system for primary supply because it calculated to be more economical than separately located vaporizers.

On the operational side, M.E.'s supervise the supply of power and services. They establish performance standards and analyze equipment for results, cost and maintenance.



Edward W. Garrison *(right) M.S. in M.E., California Tech '47, and Byron R. Brown (center), B.S. in M.E., New Hampshire '49, supervise adjustment of furnace conditions in a study of power-plant efficiency.*

Whether viewed from the design and construction side or the operational side, the diversity of Du Pont's manufacture offers a wealth of opportunities in power work for the mechanical engineer.

OPPORTUNITIES for men and women with many types of technical training are discussed fully in "The Du Pont Company and the College Graduate." For a copy, write 2521 Nemours, Wilmington, Del.

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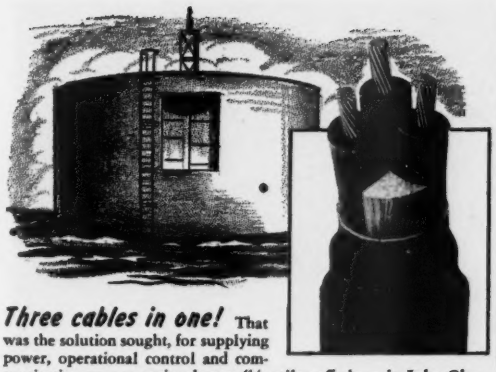

Three cables in one! That was the solution sought, for supplying power, operational control and communication to a pumping house 4½ miles off shore in Lake Okeechobee, Florida.

As usual, Okonite engineers were consulted on the problem. Their studies showed that it was possible to combine a three-fold function in one cable. This was accomplished by the use of Okolite high-voltage insulation whose electrical characteristics permitted carrier current to be superimposed on the power conductors.

The result was a single Okonite-insulated cable—steel-armored for the 4½ underwater miles, with a non-metallic sheath for an additional 2½ miles underground—which supplies not only power and operation control, but a communication circuit as well.

● ● ●

Tough jobs are the true test of electrical cable . . . and installations on such jobs usually turn out to be Okonite.

OKONITE *insulated wires and cables*

riddle of the stars

(*Continued from page 47*)

into space; often a cloud of luminous gas can be seen expanding away from the site of a nova. There are about twenty nova per year in our galaxy (the galaxy is the system comprising the Milky Way, of which the sun and all visible stars are members). If nova have been occurring at the present rate for the two billion years which our galaxy seems to have been in existence, almost every star should have exploded by now. Of course, if our sun were to explode in this violent fashion in the near future, our income tax worries would be over. But the chances are billions to one against any given star exploding in a given period of time.

The most spectacular drama the sky can present, however, is a superduper stellar explosion called a supernova. This explosion follows the same pattern as the ordinary nova. The star, however, increases its luminosity by a billionfold or more, which means that it may outshine all of the billions of stars in the entire galaxy. For one star to produce as much light as all of the ones we can see in the heavens is indeed a spectacle.

These supernova are extremely rare. The last one in our galaxy was recorded in 1604; there was also one in 1572 which could be seen in bright daylight. Chinese astronomers indicated that a supernova was visible in the daytime in the year 1054. Many astronomers believe that the famous Star of Bethlehem was a supernova.

Although supernova occur only about every three hundred years in our own galaxy, modern telescopes are capable of bringing millions of other galaxies into our range of observation. Astronomers have diligently sought to photograph a supernova in a distant galaxy. Since 1937, they have succeeded in filming more than twenty of the highly unlikely occurrences. All of the supernova observed are much too far away to permit observation of the original exploding star (the nearest galaxy is 680,000 light years, or 4×10^{17} miles from us).

The cause of nova or supernova is very much a matter of conjecture. One plausible theory which has been propounded is as follows: in the interior of a dwarf star conditions finally become possible for the formation of the completely collapsed nuclear mass which we have mentioned previously. Once some of this superdense matter has coalesced, gravitational attraction will cause the rapid collapse of the neighboring material. Within a matter of hours the entire interior of the star has collapsed into a tight core, and the enormous amount of gravitational energy is converted into radiation. The pressure of this radiation is sufficient to blow the outer layers of the star into outer space and to give the huge increase in luminosity required. This theory has not been verified in any way and is still merely an interesting guess. Nobody pretends to know the answer yet.

We see that cosmology has reached a challenging point; there seems to be a great deal of truth in the existing theories regarding stellar evolution, but there certainly are discrepancies which defy explanation. Most stars seem to be evolving in accord with the calculations of the astronomer, but some seem to be too early or too late. And some just explode for the sheer joy of it. At any rate, it gives the astronomer a nice wall of problems to beat his head against!

"Crab" Nebula in Taurus. This is probably the expanding shell of gases from the supernova observed by the Chinese in A.D. 1054.

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This huge new building pictured above is one of the world's most modern petroleum research laboratories—those of the Standard Oil Development Company at Linden, N. J. It is the research center where Esso Products are constantly developed and improved by engineers and technicians whose aim is better products for better living all over the world.

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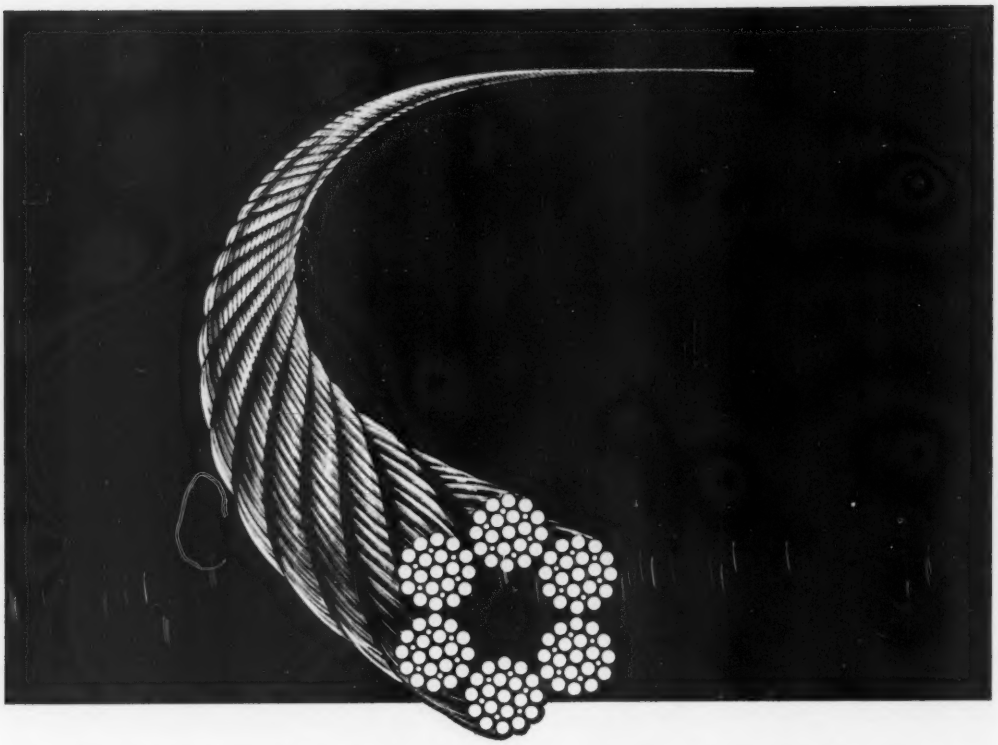

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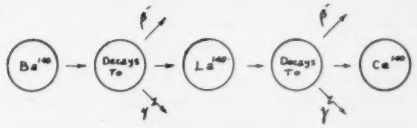
radioactive milk?

(*Continued from page 15*)

radiant energy is in many cases far more useful than the beta particles. This will be explained later. The process of beta and gamma emission is often still unsatisfactory to the nucleus and it radiates another beta particle and gamma ray, attempting to reach a stable configuration. This successive emission process is called a radioactive decay chain. Figure 2 illustrates such a chain. This is one example of many such decay chains; however, and we may expect to observe similar chains throughout our fission product spectrum.

Now that we have established the form of the radiant energy, namely beta particles and gamma rays, the question arises as to the magnitude of their energies. Beta particles emitted by fission products have energies as high as 3.5 million electron volts, an energy equivalent to accelerating such particles across a potential of 3.5 million volts. The gamma ray energies range as high as 3.8 Mev. These high energies are in general given off by fission products with very short half lives. By half life, it is meant the time required for the radioactivity of a given specimen to decay to one-half of its original value. Notice that the half life of a fission product is important because a short half life indicates large radioactivity but rapid decay and therefore frequent replenishment. The intensity of radiation is dependent not only upon the half life and quantity of material used, but also on the geometrical configuration of the material. A greater surface area to volume ratio giving greater intensity.



Ba 140 Decay Series

fig. 2.

The steps in the decay of Barium 140 into Cerium 140.

Various schemes for irradiation of the products to be sterilized have been studied. They essentially consist of passing the product through a region where it is exposed to the radiation, being rotated to avoid unequal bombardment and "burning." Great precautions must be taken to protect the operators of the radiation chamber from harmful overdoses of radiation.

The question immediately enters one's mind, won't this sterilization process cause the product to become radioactive, possibly harming the consumer. This thesis is entirely unfounded. To produce radioactivity with gamma radiation it is necessary to have energies greater than 8 Mev. except for the lightest elements. Since the conditions appropriate for induced radioactivity in the light elements are not very probable, this effect is not dangerous. The market for these fission products will be dependent to a certain extent upon competitive means of producing similar sterilization effects. One method presently in use is acceleration of electrons in an electrostatic machine such as a Van de Graaff generator. The principal objection to use of these machines is the very short effective penetration of the particles produced. To irradiate a small can of orange juice, for instance, energies of the order of 10 Mev are required. Such machines are obviously very expensive both to purchase originally and to maintain. Superior control of bombarding particles, ability to direct the radiation, and the quality of being able to turn the machine on and off are all factors in its favor, however.

The factor of depth of penetration of the different forms of radiation is of prime importance in industrial uses of fission products. It has been found that gamma rays have far greater average penetration range than beta particles. For this reason the limitations imposed by the Van de Graaff generator upon the sterilization process are removed. Even large cans of food products could be irradiated, maintaining relatively constant intensity of radiation throughout the product.

Economic feasibility of the described processes would depend to a great extent upon the decision of the A.E.C. as to pricing and safety requirements. The market for these fission products is quite elastic and because of this it would be difficult to determine price levels, as the total quantity of the material sold would

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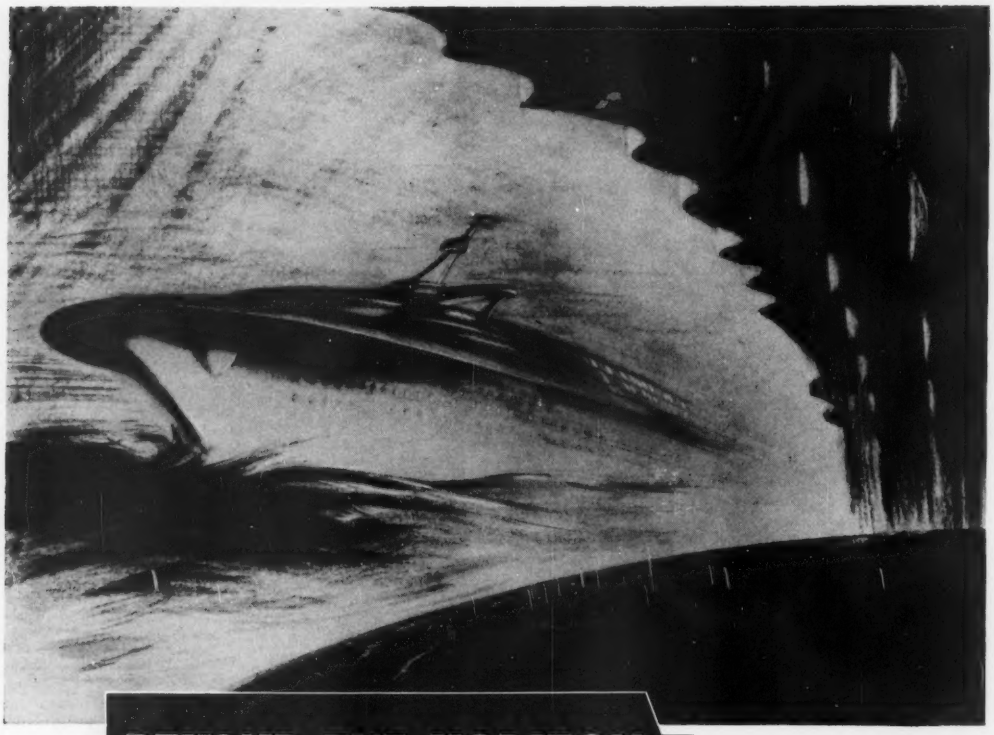

BEYOND THE HORIZON....

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MOLY

. . . dormitories!

(*Continued from page 16*)

system, believing that it is part of a student's education to be responsible for all areas of living, including the place at which he eats. However, contract feeding does have the great advantage of insuring regular eating, providing the food is of good quality. I have been among those who have complained because of poor tasting food; but it must be admitted that Institute food has improved remarkably this past term, until it is now at least as good as any other dining service. Presumably it will continue to improve.

One of the joys of dormitory living is Pritchett Lounge, the snack bar located on Walker's second floor, and the Burton House and Graduate House snack bars. Here, in a bright atmosphere, you may have anything from a soft drink or ice cream to a light meal. Each place really is appreciated after an evening of study.

Safeguarding student self-government within our living group is the principal purpose of the dormitory house committees. The past year was a notable one for the committees, involving recommendations concerning food, the purchase of a new enlarger for a photographic darkroom, the purchase of the pool table, and a general expansion of lounge and athletic facilities. This committee determines how the money you give towards such dormitory activities is spent. Consequently it is important for you to select wisely when choosing the representative from your hall or floor and to participate in its meetings, which are open to every resident.

Available for help are your upperclassmen freshman advisors. You will get to know them during Freshman

Week; feel free to ask them for help throughout the term. For that matter most upperclassmen will be happy to help you with any problem, scholastic or otherwise, without trying to tell you what to do. That is the primary reason why freshmen at M. I. T. dormitories live amongst upperclassmen and not by themselves.

It should be obvious by now that there are many opportunities available for self responsibility in choosing activities and general living available at the dormitories. One not yet touched upon is your opportunity to meet and learn to get along with many students from outside your own social, regional, or religious background, an opportunity not always present in other living groups. Living remains thoroughly democratic, however, and this opportunity for democratic living is for myself an outstanding opportunity presented by college. I hope you will take advantage of it.

. . . fraternities!

(*Continued from page 17*)

Also, there are other important phases of college life: athletics and recreation. The fraternity man, like his dormitory friends, can participate in a variety of intramural sports. He competes against other fraternities for the league championship. Of course there are many impromptu sand-lot ball games which spring up when the weather seems to banish any thought of classes. And there is usually a ping-pong game in progress in the House's game room, where a bridge game is also likely to be in session.

The major sport at Tech, however, is the indefinite pastime known as "goofing off". The fraternity house offers fine facilities for killing any amount of time. There is a record collection to choose from or television to watch. The House living room is just the place to loaf; the comfortable chairs seem to promote bull sessions.

The other major indoor sport, eating, is equally popular. Raids on the House icebox occur at all hours of the night and day. Having all meals served in your own House makes them much more pleasant and also saves a considerable amount of time and money. The dining room is one of the most popular places in all houses.

The House, then, is far more than just a place to study (although this is one of its most important functions). It provides its members a place to loaf, play, or bring friends. Although the members have outside interests as well, the House is almost always the most important organization they belong to. Its facilities for recreation and social contacts will make the member's years at Tech more pleasant than they would have been otherwise.

But the more lasting benefit a fraternity member will carry with him from college is the lasting friendship of a group of fellows he lived with for four years. These associations will stay with him for the rest of his life. The way he spent his college years is as important to him as what he learned. And, unlike most of the facts he absorbs in classes, it is something he won't forget.

(Above) The perpetual bridge game in one of the dormitory lounges.

(Above, left) There is nothing like a piano to make fraternity fellows feel fraternal.

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Age-old natural gas—changed beyond recognition by the hand of science—is in nearly everything that's new today

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robot chess

(*Continued from page 19*)

counter" and symbolized by j_p. It must be distinguished from the "piece number" p which characterizes the six different pieces irrespective of color, for instance, as follows:

Pawn	King	Knight	Queen	Bishop	Rook
1	2	3	4	5	6

We can now describe any particular position by means of a list consisting of 32 consecutive lines which we will number a, $a+1$, $a+2$, . . . $a+31$, and which are so allocated to the 32 pieces, that line $a + j_p$ corresponds to the piece with the piece counter j_p. Each of these lines contains the number s of the square on which the piece is to be found; if the piece is not on the board at all the line will contain some special symbol, e.g., a negative number, indicating this fact. This list will be referred to as the "a-table."

An additional list, the "b-table," describes a position in a different way. It allocates successive lines, say, b, $b+1$, $b+2$ . . . to the squares on the board so that line $b + s$ corresponds to square No. s, and contains information regarding the piece occupying this square, such as its piece counter j_p, its piece number p and a special symbol indicating its color. A further symbol is used if the square in question is empty.

Moves from one square s to another square t are made by adding certain numbers to the original square number s to obtain t. For instance, we may allocate numbers from 0 to 63 to the 64 squares; then a move one step to the right will be effected by the addition of 1, one step upwards by the addition of 8, etc.

However, this scheme involves a particular difficulty when we come to the edge of the board. When the machine has, say, reached square 7 and tries a step to the right, it will compute the new square as 8 which is obviously wrong. We must, therefore, devise a scheme which will tell the machine when the edge of the board is reached. The solution is indicated in Figure 2 which shows a 10×10 board in which the squares are numbered from 0 to 99. Of these 100 squares, only the central 64 constitute the proper or active board while the remaining 36 form a border. If s is the number of a border square then line $b + s$ will contain a symbol informing the machine that the limits of the active board have been exceeded.

A single-step move to the right is still carried out by the addition of 1, but a single step upwards now means addition of 10. To move diagonally upwards and to the right, we have to add 11. In general, there is a direction number d associated with each of the possible 8 directions. Counting these directions by a direction counter j_d, we can put successive numbers of d into successive lines $c + j_d$ of a list starting with line c. Beginning with moves to the right, and proceeding in an anti-clockwise sense, we thus get the following "c-table" or "direction table":

j_d	*Line No.*	d
0	c	+ 1
1	$c+1$	+ 11
2	$c+2$	+ 10
3	$c+3$	+ 9
4	$c+4$	− 1
5	$c+5$	− 11
6	$c+6$	− 10
7	$c+7$	− 9

The "step counter" j_s counts the number of steps of a move in a given direction. A move of j_s steps in the direction d is produced by the addition of the product $d \times j_s$ to the original square number s. For the King and, according to the restrictions imposed on the program, for Pawns as well, j_s can only have the value 1.

Knight's moves are composed of horizontal or vertical single-step moves, followed by a diagonal single-step move. In principle, the same direction table can be used, but in practice it has been found more convenient to have a separate list.

In addition to j_p, j_d and j_s, there is a color counter j_c which decides whether the machine is making a white or a black move. The values of j_c have been chosen as 0 for white, 16 for black. This choice is related to the fact that corresponding white and black pieces are 16 lines apart in the a-table. Instructions modified by j_c will select a piece of the correct color from this list.

In what follows it will be convenient to talk about a first and second, white and black turn, during each of which a number of moves are tried out. With this nomenclature, White tries out all its first-turn moves until a solution is found. Black answers each of these moves with his first-turn moves until one is found for which no white second-turn move leads to a mate, and so on. A more detailed analysis of the structure characterizing the mate-in-two problem is given at the end of this article.

Let us now consider the case that White has made a number of first-turn moves without finding a solution. How does the machine construct the next first-turn move? White's last first-turn move was characterized by certain values of s, p, j_p, j_d and j_s (j_c being zero) and the machine has stored these numbers, together with the a-table and the b-table describing the original position, in the magnetic store in order to free the electronic store for the information needed in the moves tried out during the other turns. At the beginning of the new move, all these data are transferred back into the electronic store.

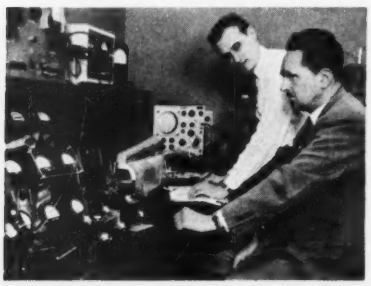
The machine then starts by looking up the line containing the piece number p. Under the control of this number, it will then enter a sequence related to the piece having this number. If, for instance, $p = 5$, it will enter the sequence for Bishop's moves; they are characterized by odd direction counters. Next, the step counter j_s is increased by unity (except when p indicates a Pawn, Knight or King). Then the machine finds the number s of the square from which the last move had been made and the previous direction counter j_d. By means of these numbers, the machine forms the sum $t = s + d \times j_s$; this is the number of the square reached by the new move (which goes one step further than the previous one in the same direction).

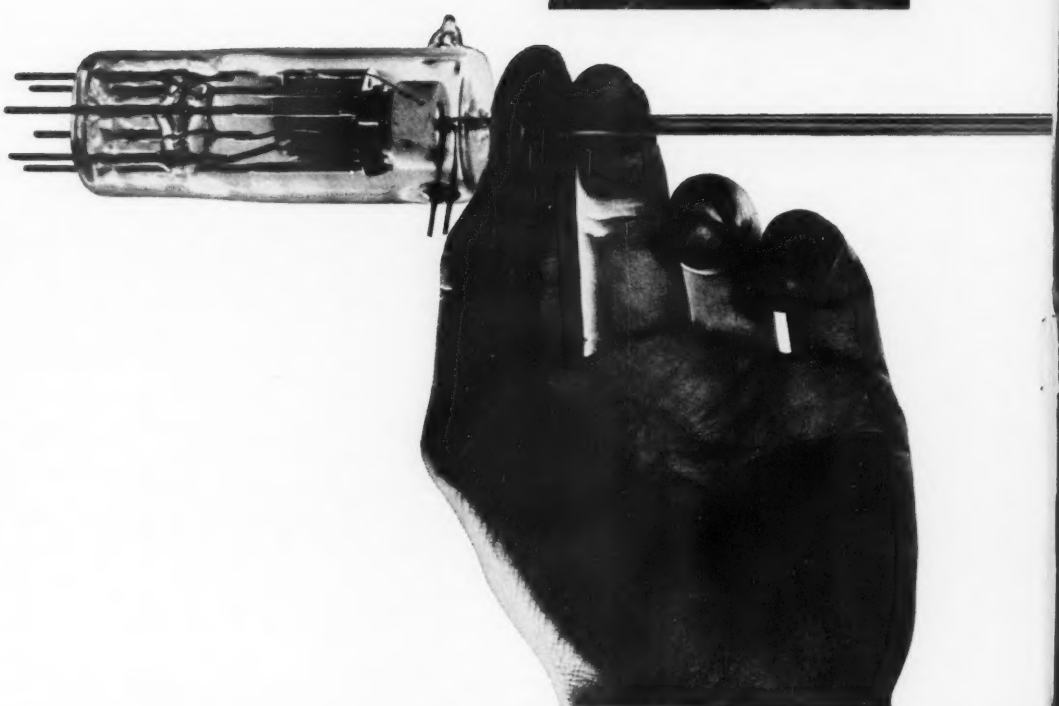
Having found t, the machine looks up the b-table to examine the contents of this square. It may turn out that this square is one of the border squares, or that it is occupied by another white piece, in which case the move has been found to be impossible. We shall deal with this case later and assume for the moment that the new square is either empty or occupied by a black piece, i.e., that the machine has found a possible move. Under the control of the symbols for "black" or "empty" which the machine has found in line $b + t$, it now enters a routine to test whether the move is legal, i.e., to ensure that the move has not put the white King in check. This is a complicated process the description of which must also be deferred for the moment. If the move turns out to be illegal the machine returns to the

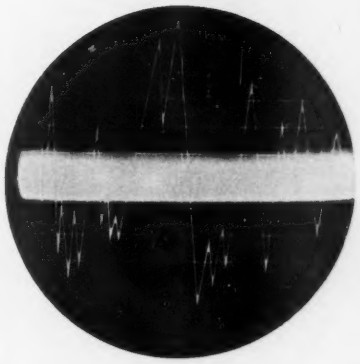
(*Continued on page 63*)

Reducing **noise** in radar...

Measuring the noise figure of an experimental traveling-wave tube are Dr. A. V. Haeff (right) head of the Electron Tube Laboratories at Hughes, and Dr. Dean Watkins (left) one of his co-workers.







In the operation of a radar system, the amount of energy reflected from small targets is very minute. The over-all sensitivity and range of radar depend equally upon effectively generating and transmitting considerable power at microwave frequencies—and upon effectively receiving and amplifying very weak echo signals.

An important limitation in receiver sensitivity is imposed by noise that is created within the receiving tubes—and caused by random motion of electrons. Because the reduction of tube noise could make available improved techniques to the designer of many types of microwave systems, a project is under way at Hughes Research and Development Laboratories to expand our understanding of noise phenomena at high frequencies.

Studies in tube noise are being made with the newly developed *traveling-wave tube,* shown on this page in actual size. This tube has the unique ability to amplify microwave signals over a wide frequency range, but its excessive noise has hitherto prevented its extensive use. Methods of reducing noise in the traveling-wave tube are being devised and tested at Hughes, and the recently obtained noise figure of 13 decibels at a frequency of 10,000 megacycles is proving of considerable interest to systems designers.

Positions for engineers and physicists are available in the Research and Development Laboratories. If you would like to learn more about these positions, and are not now engaged in an urgent military project, write to:

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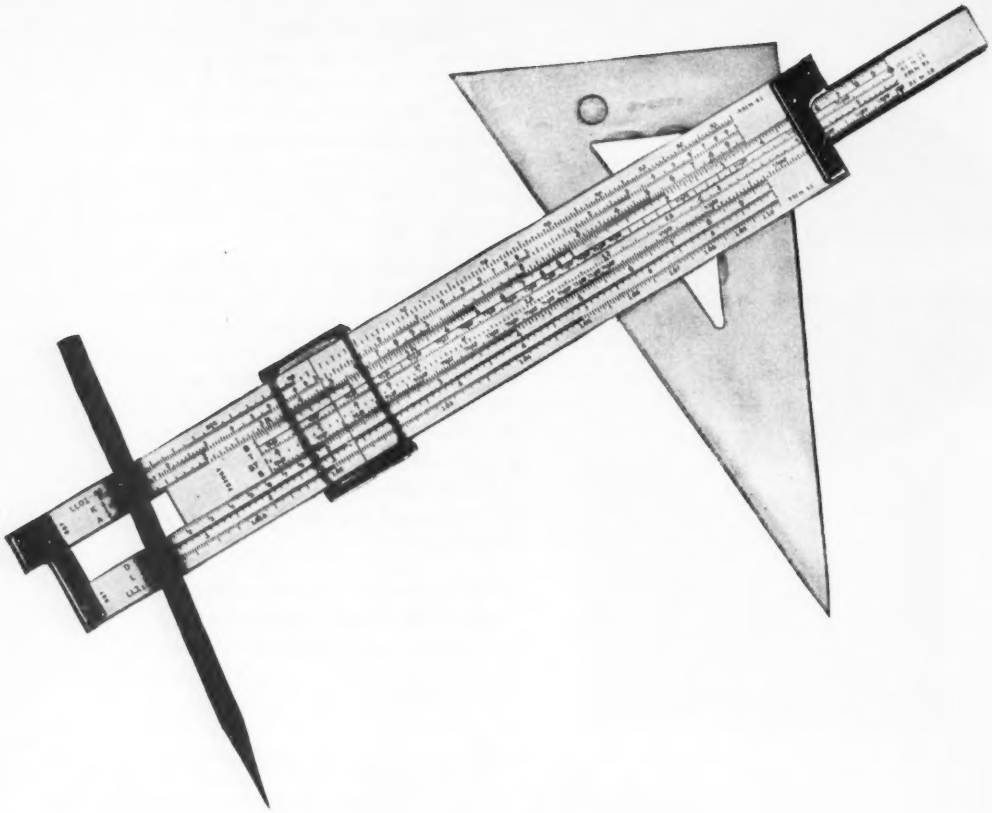

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(*Continued from page 59*)

process of counting up and trying out the next move. If it is legal then the new position (possibly also modified by the taking of the black piece on square t) is recorded by suitable entries in the a-table and the b-table, and both these tables, together with the new values of the counters, are transferred to the magnetic store. Later, the new position will be used as a starting point for Black's first-turn moves, while the new set of counters will indicate the next move to be made when it is White's first turn again.

Let us now return to the case where a tentative move made by the machine is found to be impossible, as indicated by the symbols ("border square" or "white") found in line $b + t$. The machine will then increase the direction counter by a number depending on the piece, e.g., 1 for King or Queen, 2 for Bishops or Rooks. Again, there are two possibilities. If the new direction counter does not exceed its maximum value 7, the machine will try a single-step move in the new direction and then proceed as before. If j_d does exceed this number, indicating that all possible directions for this piece have been tried out, the machine is made to enter another sequence which increases the piece counter j_p by 1. Once more, we have two different cases. If the new j_p exceeds 15, i.e., if all the 16 pieces have been dealt with, then the position is exhausted; for the white first-turn moves, this means that the problem has no solution at all and the machine will be made to stop or to print out a remark to this effect. If, on the other hand, the new j_p does not exceed 15 then the machine examines line $a + j_p$ in the a-table. Here the process divides again. If the contents of this line indicate that the piece with the counter j_p is not on the board at all, the machine will increase j_p again and go on as before. If the piece is on the board, then line $a + j_p$ will contain the number s of the square containing this piece. The machine will then record j_p and s in their proper storage lines, and it will look up line $b + s$ in the b-table where it finds the piece number p. This is also recorded and the machine goes back to the process described initially, i.e., to a sequence constructing a new move appropriate to the piece p, but in this case a single-step move in the first of the possible directions.

The same processes occur in the other three turns of the game, and it is only necessary to add that the first move in any turn is preceded by resetting the counters to their initial values.

The routine for testing leg·lity uses techniques similar to that for finding the next possible move. Assuming we are in a white turn, the machine starts by examining the contents of line $a + 15$ where it finds the square on which the white King stands. From this square as a starting point, the machine then explores the board by a series of imaginary moves, leading to various squares t. By looking up line $b + t$ in the b-table, the machine then finds out whether t is outside the active board; if not, whether it is empty; and if not, whether the piece standing on it is white or black. Except for the last case, the machine will then immediately construct the next imaginary move. In case of a black piece, the machine examines whether the rules governing this piece are in such a relation to the move just made that the King is under attack. Thus, a black Rook can endanger the white King only if the imaginary move just made had an even j_d; for the black King, j_d must have been 1; and similarly for the other pieces. (Knights are treated in a slightly different way; the machine makes imaginary Knight's moves and tests whether or not the value of p, found in line $b + t$, equals 3, the piece number allocated to Knights.)

The move is illegal if a piece attacking the King can be found; it is legal if the process exhausts the position without finding such a piece. As mentioned before, the need for scanning the greater part of the board whenever a move is made makes this process one of the most time-consuming operations in the program.

We have seen that the program for the solution of mate-in-two chess problems must contain a routine for the construction of the next possible move, a routine to check this move for legality, and various sequences for recording the moves made and the positions obtained. All these pieces must now be linked together by a master routine reflecting the structure of the problem as a whole, and ensuring that the various turns are entered in the correct sequence.

This structure is illustrated by the diagram in Figure 3. Each of the 4 blocks marked W1, B1, W2, B2 represents one of the turns. Each block is provided with two "entries" 1, 2 and two "exits" 3, 4. Entry 1 corresponds to the case of the first move in a turn, with all the counters set to their initial values. Entry 2 is the general case of a move following a previous move of the same turn. Exit 3 indicates that a legal move has been found; exit 4, that the position supplied to the turn has been exhausted before such a move has been found.

Let us look at the diagram in detail. Right at the beginning, turn W1 is entered at 1. Normally, it will find a legal move, and its exit 3 will lead to entry 1 of B1, the first move in Black's first turn. If B1 finds a legal move, its exit 3 will lead to entry 1 of W2, and similarly, a legal move of W2 will lead from its exit 3 to entry 1 of B2.

If now B2 finds a legal move (exit 3) then White must try another second-turn move, i.e., exit 3 of B2

(*Continued on page 66*)

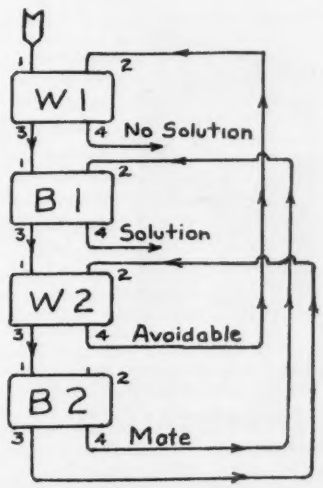

Fig. 3. Symbolic diagram, explained in the text, showing how the machine solves the entire mate-in-two-moves problem.

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ruts of stagnation

(*Continued from page 23*)

personal annual report only in terms of sound mortgage loans and capital gains.

Other worthwhile stagnation slayers are available in the form of active membership in your professional society so that you are exposed to new developments in your field. Indeed, this is the very purpose of the professional societies. Unless you want to develop a one-track mind (*i.e.* stagnation in every field but that of your major interest) expose yourself to a little learning in some unbelievably irrelevant field: say, a University Extension course in Medieval painting.

Gladstone — whose heart never dropped its leaves — began the study of Greek at age seventy and completed a translation of the odes of Horace when he was eighty-three. Such men never have hardening of the mental arteries because they refuse to stagnate. Recognizing that the things they did and the ways they did them are worth working hard for, they worked hard. Or, if you must stagnate, do it uncomplainingly.

Professor Morris, resting with geologic solidity on the canons of sound psychology, recommends a worthwhile spree as a stagnation slayer — not the kind of spree that brings about hazy perception, dulled sensitivity, tortured talk, and sundry sinks of inquiry; but the kind of spree that gives one a new enthusiasm, a throbbing interlude breaking a deadly routine, genial communion with poetry, music, drama. An evening devoted to such poets as Kipling, Eric Mackay, Ernest Dowson, even Dorothy Parker; or the music of Schubert and Tschaikowsky, dripping with emotion, has its place in a world beset with the pitfalls of stagnation.

Get outside of yourself, away from yourself, free from yourself once in a while. Otherwise, like the family Leguminosae, because the peas were green and the pod was green, you will think the whole world is green.

"That's all very well," you say, yawning magnificently, "but I'm not afraid of stagnation." Oh ye of little perception; unless you feel a premonitory prick of panic at the very thought of stagnation, its sweet and soothing paralysis is already upon you.

To the man who ever keeps his nose to the monotonously revolving grindstone, every moment is like every other moment and the ruts of stagnation have swallowed him already. For his own sake, as well as for the safety of the business, he ought to be fired. It may shake him out of his rut. To the man who is still vitally alive, sensitive to new truths, eager to see the other side of the mountains, only those inspired moments are worth counting in which there is the zest of new beginnings or the mile post — never the final goal — of new achievement.

Most men begin to stagnate, religiously for example, by the time they reach college. The process is pretty universal and complete before age forty. This is one good reason men have to die. The old grey mare was plenty good enough for father, no automobile for him. I drive my car fifteen thousand miles a year and lift an eyebrow at the airplane. Old *terra firma* is plenty good enough for me and the more firmer the less terror. But son Richard sighs for the joy stick and an ampler age when Dad's stuttering explanations of why he should keep his feet on the ground will no longer be effective.

We reject the very need for change and have to die in order that a new generation may accomplish it. The faithful old employee who has been with the company so many years didn't get the promotion. "That's the heartless ingratitude of business for you," everybody declares with some asperity. Everybody? No, not those who realize how many years ago the faithful old employee became completely stagnant. To promote him would be suicide for the company.

You seniors will soon be looking for jobs. Accept the best financial offer? Not of that basis alone if you are wise. What has happened to the forty-year-olds in the company? Are they on the way up or on the way out? If the latter, don't accept that offer; the company buries its youngsters in the ruts of stagnation.

Go to work for Dad? Not right out of college if you know your psychology. Dad brought you up in the fear of God; that is to say, what Dad thought was right, and he will complete the process by saddling you with most of his pet business ideas. Listen to the ominous drum-beat of threatening stagnation; go to work for Dad's deadly rival; and after five years in the old factory go back home. Then you may be able to shake the old man out of *his* rut instead of letting him pull *you* in.

Remember that education is a system of habits for growth which must be a lifelong process. When you stop growing, death, be it physical, mental, or spiritual, begins. "The only difference between a rut and a grave is in their dimensions."

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milk

(*Continued from page 55*)

have a marked influence on the cost of separation and packaging for transportation. The immediate outlook appears that such industries as the manufacture of high value drug products and specialty foods might well profit by the introduction of these methods. In a few years hence, refrigeration and heat sterilization may be a means of past generations.

glass

(*Continued from page 25*)

of the drawing. Long strips of wide lead are placed against these wooden bars, and beginning in the corner, a piece of glass is fitted into the grooves of both strips of lead. A strip of smaller lead is now cut long enough to cover the opposite side of the glass and it is bent into shape, inserting the glass into one groove. Into the free groove of this lead the next piece of glass is inserted, and so on until all the pieces are leaded. Then all the joints are soldered on both sides.

The window is now one piece, but it must be cemented in order to make it rigid and make it thoroughly watertight. It is laid on a bench and completely covered with a waterproofing cement, composed of Portland cement, whiting, lampblack, boiled linseed oil, turpentine, and a patent drier. With a stiff brush the cement is forced under the leads on both sides of window, and after cleaning off glass with sawdust, cement is allowed to dry and harden.

To prevent the window from bulging and sagging, horizontal bars are fastened into the window sash at intervals, and to these bars the window is joined by small pieces of copper wire soldered to the lead at joints and twisted around the bars. Often these bars are bent to conform with the design of the window, and in some types of windows, the bars are a governing factor in the design, where these heavy black lines give contrast to the color and strengthen the design. In order to give the window additional strength, it is made in sections not more than three feet high. Heavy Tee bars are fastened into the grooves, and each section (except, of course, the bottom one) is supported by one of these horizontal Tees. These small sections also facilitate the shipping of large windows.

In installing a window, the glass worker is frequently confronted with difficulties. When a window is to be set in stone, the grooves are sometimes made too shallow, and the worker finds it necessary to take the window apart at various places in order to insert the glass into the grooves, later resoldering and recementing the glass. Whenever the stonework is intricate in design and construction, this cutting apart cannot be avoided. However, if the grooves are made deeper on one side than on the other, the setting will be made easier, for after inserting the glass into the deeper groove, it can be pulled back into the opposite groove without any great difficulty. A stop bead is used to hold glass in wooden sash, while small metal clips are screwed into metal casements to make the glass secure.

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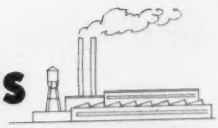

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(*Continued from page 35*)

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robot chess

(*Continued from page 63*)

must go to entry 2 of W2, but if B2 finds no legal move, Black is mate (or stale-mate) and must try another first-turn move. This means a connection from exit 4 of B2 to entry 2 of B1.

If, after a first-turn move by Black, White tries out all its second-turn moves without achieving mate, then White must try another first-turn move; this gives the connection from W2, exit 4, to W1, entry 2. On the other hand, if after a W1 move Black exhausts the position without finding a move avoiding mate, then this move by White was the key move; for this reason exit 4 of B1 is marked "solution." No solution exists if W1 tries all legal moves without finding one leading to an unavoidable mate; this is exit 4 of W1.

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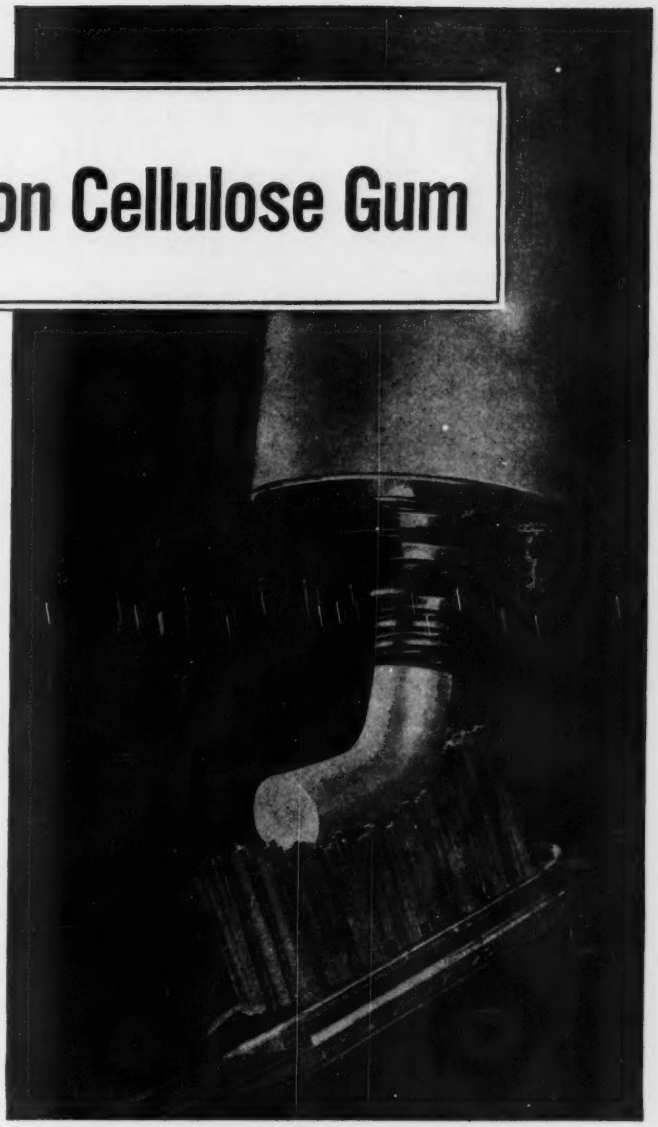

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Physics

Quantitative Biology

Science Teaching

SCHOOL OF HUMANITIES AND SOCIAL STUDIES

Economics and Engineering
- Courses:
  - Based on Mechanical Engineering
  - Based on Electrical Engineering
  - Based on Chemical Engineering

SCHOOL OF INDUSTRIAL MANAGEMENT

Business and Engineering Administration
- Courses:
  - Based on Physical Sciences
  - Based on Chemical Sciences

The duration of each of the above undergraduate Courses is four academic years and leads to the Bachelor's degree, with the following exceptions: (1) Architecture, which is a five-year course leading to the Bachelor's degree; (2) Chemical Biology, Food Technology (Five-Year Course), Physical Biology, and the Cooperative Course in Electrical Engineering, which extend over a period of five years and lead to the Bachelor's degree and the Master's degree; (3) Science Teaching, which is of five years' duration and leads to the degree of Bachelor of Science from the Massachusetts Institute of Technology and the degree of Master of Arts in Teaching from Harvard University.

Graduate study may be pursued in Textile Technology, Ceramics, Sanitary Engineering, and in most of the above professional Courses. The Master's and Doctor's degrees are offered in most of these fields.

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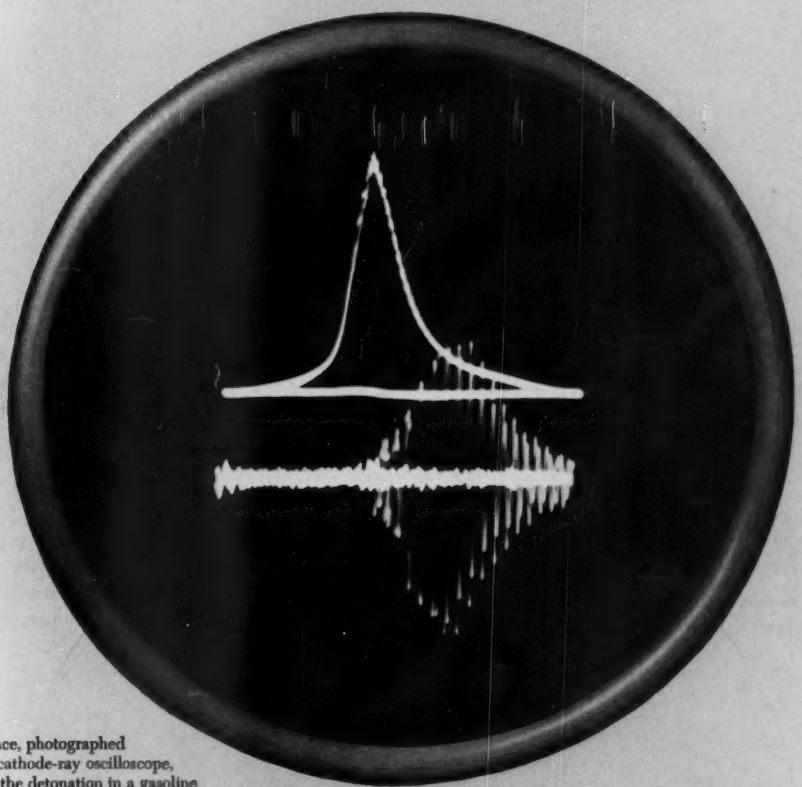

This trace, photographed from a cathode-ray oscilloscope, depicts the detonation in a gasoline engine cylinder.

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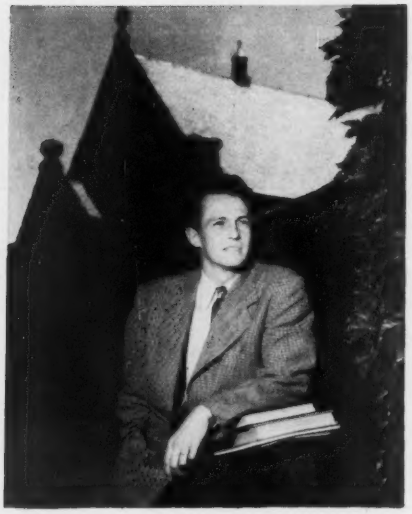

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